POWER PLANT ENGINEERING

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The New Plant of the H. H. Franklin Mfg. Co.

UNIQUE SOLUTION OF HEATING PROBLEM; GENERATING EQUIPMENT INSTALLED TO SATISFY THE DEMAND FOR EXHAUST STEAM

FOR YEARS THE PLANT of the H. H. Franklin Mfg. Co., in Syracuse, N. Y., received all of its electric power from the lines of public service companies, while its heating requirements were met by the company's own boiler plant. The electrical power, being mostly from hydroelectric sources, was supplied at so low a rate that the company did not attempt to compete by generating electric power for its own needs. As the plant grew, however, the increased demands for heat, both for keeping the factory comfortable for the workmen and for process work, demanded the building of a larger boiler plant, and at this time the problem of generating electric power as a by-product was considered. As the result of considerable investigation and engineering calculation, it was decided to build and equip an entire power plant designed with the object in view that the plant was to generate only that amount of power which would give the amount of exhaust steam required for heating and process work, the remaining power demands being supplied from the local central station.

The problem is unique in that the generating units

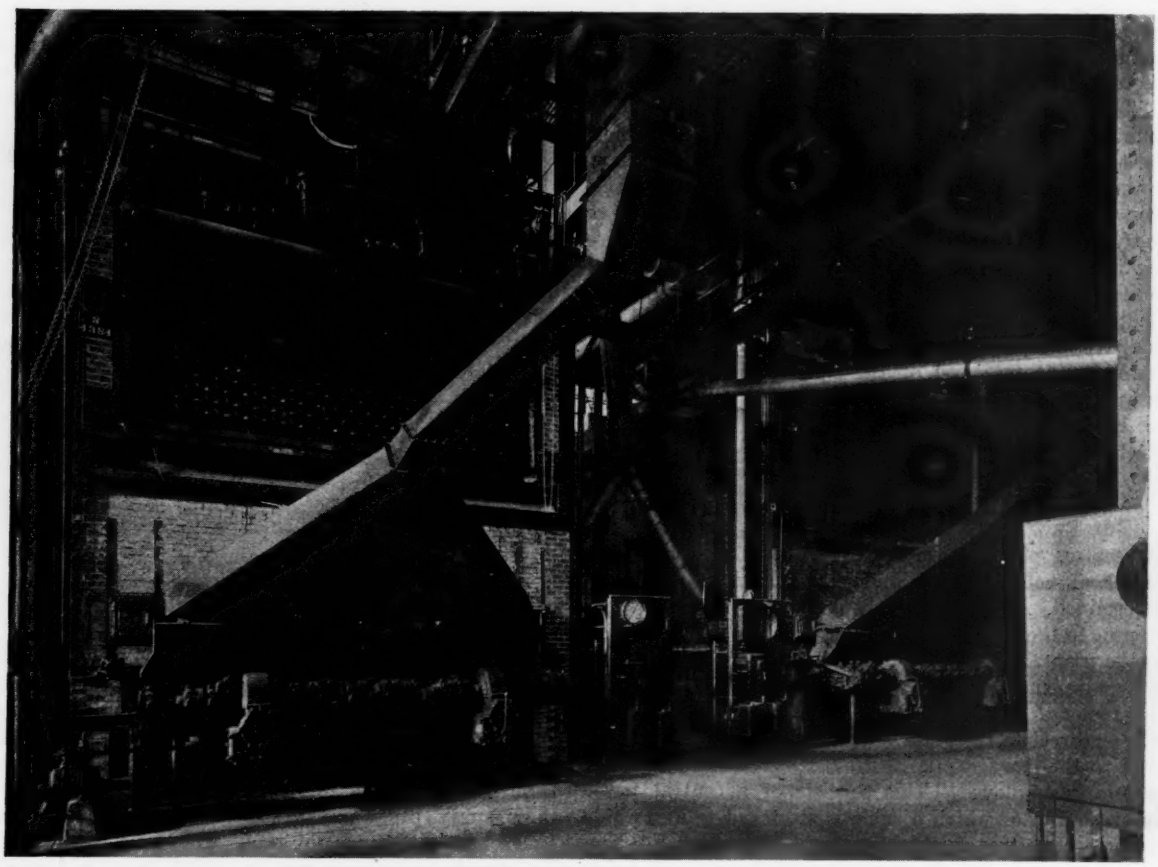


FIG. 1. THE BOILER ROOM, SHOWING TWO-SPEED, TWO-SECTION STOKERS

which are turbine driven are to take the place of reducing valves and at no time is it expected that steam will go to waste either or to condensers, for, when the exhaust steam exceeds the demand, power will be taken from the city lines, reducing the load on the turbines with a consequent reduction in exhaust steam produced.

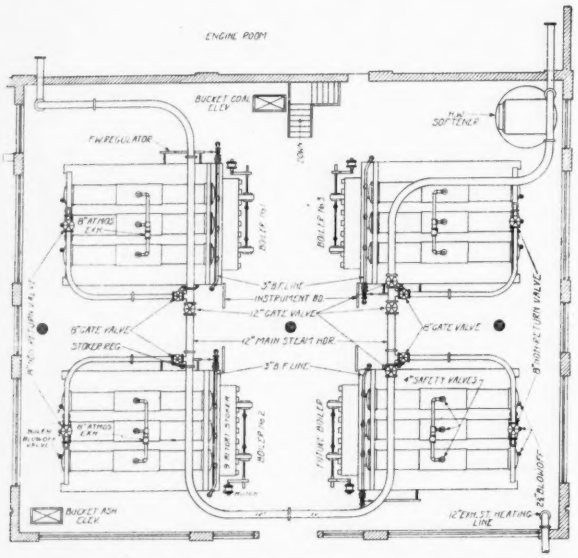


FIG. 2. BOILER ROOM, FIRST FLOOR PLAN

This solution to the problem was made possible only through the co-operation of the local central station which secures a great share of its power from the hydro-electric plants at Niagara Falls.

The original factory, like many in that section of the country, was wired for two-phase, 440-v. circuits which were supplied from the local distributing system through Scott connected transformers. This system, however, proved to be expensive in the use of copper and as new factory buildings were added, all new wiring installed was put in conduits and is of the three-phase, 440-v. system, and all motors and other equipment in the new parts of the factory are designed for this class of service. In the old parts of the factory, however, the majority of the equipment still requires two-phase circuits, but this equipment will gradually be replaced with three-phase equipment as new machinery is required.

Coal and Ashes

The new power plant is in the same location as the old heating plant which was found to be as near to the center of both the heat and power loads as could be determined, and is also conveniently located with respect to the railroad siding, on which coal is delivered to the plant. The fuel purchased is bituminous run-of-mine supplemented with a small amount of refuse from the factory. This coal may be delivered to a storage pile or direct to the plant. For handling the coal delivered to the storage pile, a Blaw Knox tower and cable system is employed. This consists of a central tower from the top of which a cable is stretched to a movable tower which travels on a crescent shape track. The cable carries a grab bucket, operated by a small hoisting engine, which is used in storing the coal from the cars and in reclaiming from the storage pile. In the latter process, the coal is loaded on a car which runs by gravity down a slight grade to the power plant there to be dumped into the track hopper discharging to an apron feeder which carries the coal to a crusher. To return the car for refilling at the storage pile, the hoisting engine is used to draw the empty car by means of a cable. By means of this equipment and the space available, 5000 T. of coal may be stored.

Coal which goes direct to the plant in railroad cars is dumped into the same hopper that receives the coal from storage and from this point is delivered, as stated before, to the crusher by means of an apron feeder which in turn discharges to a belt conveyor, thence to a bucket elevator which carries the coal to a scraper conveyor for distribution in the boiler room bunker located over the firing aisle. All of this coal handling equipment in the power plant was furnished by the Stephens-Adamson Mfg. Co., and is capable of handling 50 T. of coal an hour.

From the bunker, which has a capacity of 600 T., coal is drawn through Richardson automatic scales, a set of which is provided for each boiler, and discharged through chutes to the stoker hoppers. These scales are readily accessible for inspection or repair by a well designed system of suspended steel gratings and ladders, all equipped with hand rails. While this system of feeding coal to the stokers is probably a bit more elaborate than that found in most plants, it has the advantage of being absolutely reliable. The scales operate by gravity of the coal which is to be delivered to the stokers and requires practically no power. The operating mechanism is simple and requires no care except, perhaps, a daily inspection. At the outer end of the bunker an additional chute is provided to discharge

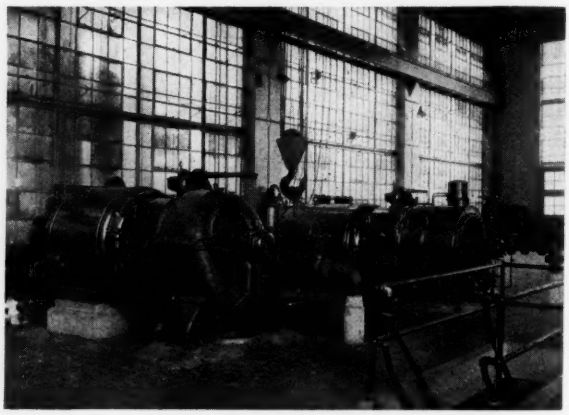


FIG. 3. PHOTOGRAPH SHOWING TWO TURBO GENERATORS

to a monorail car by means of which coal is delivered to the heat treating plant of the factory.

The ash pits beneath the rear of the stokers are of reinforced concrete and are provided with a 1¼-in. water pipe for spraying the hot ashes and a 2½-in. perforated low pressure steam pipe extending the width of the setting just below the bridge wall to prevent clinkers from adhering to the bridge wall. The perforations in these spray pipes are ⅛-in. located on 6-in. centers. Each ash pit has two gates which drop the ashes directly to industrial cars in which they are carried on tracks to the hopper of a Stephens-Adamson bucket

elevator; this delivers them to a reinforced concrete ash bin just outside the boiler room, 13 ft. 6 in. by 10 ft. 4 in. by 20 ft. high. Trucks driven under the bin receive the ashes for disposal. Between the second and third passes of the boiler is a chamber where soot collects to some extent and from this chamber a chute leads to the basement where it discharges to the industrial ash cars taking the same course to the ash bin.

At the present time, the plant is provided with three 605 hp. Edge Moor water-tube boilers with space allowed for one more of the same size. Steam is generated at a pressure of 210 lb. per sq. in. gage. No superheaters are installed. The boilers each have three steam drums and are vertically baffled so as to secure four passes of the gases over the tubes before they go to the breeching which extends across the ceiling of the basement to the stack. The front headers of the boilers are normally covered by a steel roll curtain which, however, is easily rolled up out of the way in case the headers are to be inspected or repaired. For keeping the tubes clean, eight units of Vulcan soot blowers are installed on each boiler.

Bernitz furnace wall construction is employed in the furnace walls of all boilers. This consists of an arrangement of specially perforated fire brick laid around the furnace at and a short distance above the fuel bed. Air, forced through the tuyere-like openings in the brick, not only supplies the necessary oxygen above the fire bed to effect combustion of the volatile gases, but also serves to keep the sides of the wall at that point comparatively cool and thus prevents the adherence of clinkers. This Bernitz construction is also provided at the back of the furnace at the bridgewall.

The boilers are served by Riley nine-retort underfeed stokers which are driven by individual variable speed, General Electric Co. induction motors. Each stoker is divided into two sections, a two-speed gear box being provided for each section, thus making it possible to feed more coal to one side of the furnace than to the other in case it is found necessary.

The details of this arrangement are clearly shown in the photograph, Fig. 1. The driving motor of the stoker, shown at the extreme left is geared to a lay shaft running along the furnace front and passing through the two gear boxes. The range of speeds secured by this combination of gear boxes and the four speeds of the motors give a wide range of service to the stokers.

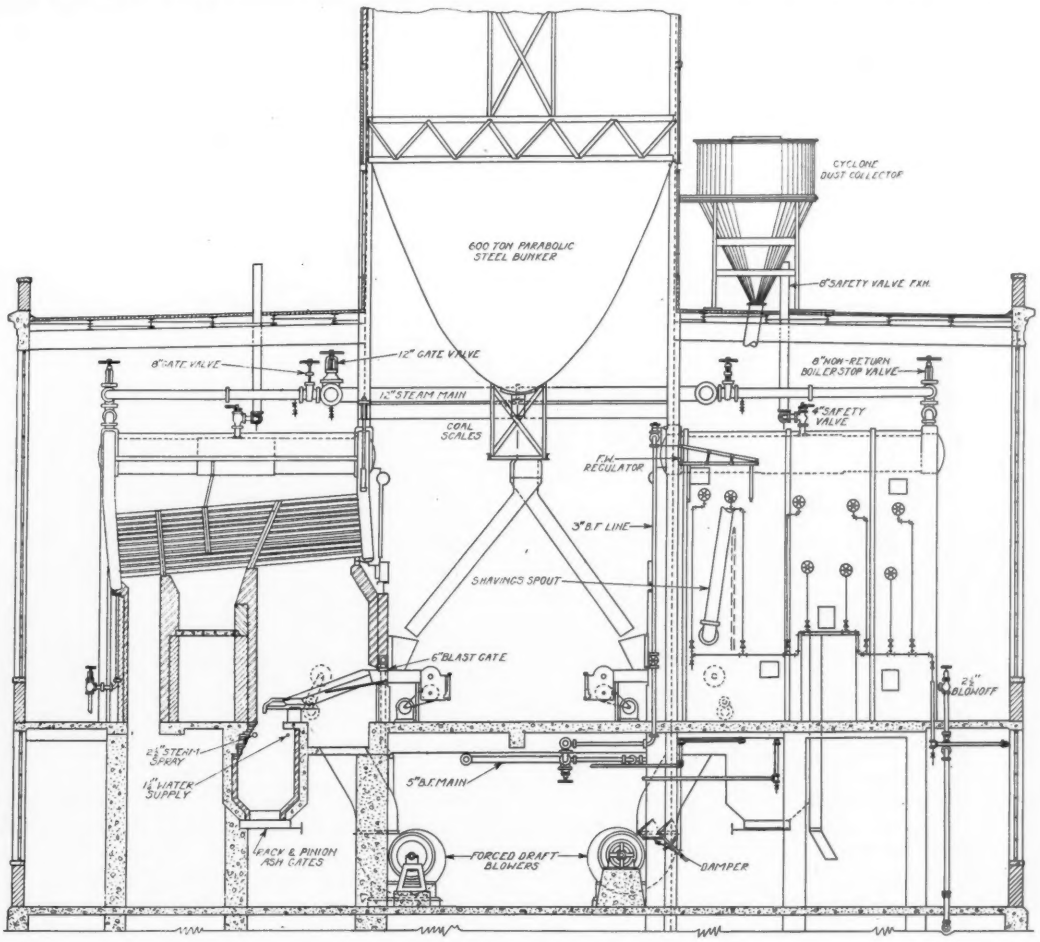


FIG. 4. SECTIONAL VIEW OF BOILER ROOM

Wood Fuel

In addition to the stokers, the boilers are fitted with an arrangement for burning wood waste such as sawdust and shavings. A limited amount of this waste is available from the wood working shops, but the supply is more or less unsteady, and no great amount of depen-

dence is placed upon this type of fuel. The waste is delivered into the furnaces above the fuel bed through spouts in the side walls. These spouts may be seen in the photograph of the boiler room, Fig. 1. There are three spouts, one for each boiler, all being supplied from a single cyclone separator in the upper part of the boiler room. The shavings are delivered to the boilers directly underneath the cyclone by gravity, but to deliver them to the boiler on the opposite side of the firing aisle, a small motor driven blower is employed.

Forced Draft

Forced draft to the furnaces is supplied by means of Sturtevant fans, one being provided for each boiler. These, as may be seen by reference to Fig. 4, are located in the boiler room basement almost beneath the furnaces. Each fan is separately driven by a 40-hp. variable speed General Electric motor, normally operated, however, at 1140 r.p.m. Air is delivered directly from the fans to the furnaces.

grates and removes the products of combustion from all of the boilers.

Boiler Blowoff Piping

Each boiler is fitted with three 2½-in. blowoff lines, one for each drum. These lines pass downward through the boiler room floor and connect into 4-in. blowoff headers in the basement, one for each line of boilers. A 2½-in. blowoff valve is fitted in each of the three branch lines at a point 3 ft. above the boiler room floor level. The two 4-in. headers in the basement merge into a single 4-in. line and pass out to the sewer.

Boiler Feed Water

The condensate from the heating system of the entire plant is returned to the boiler room, partly by gravity and partly by means of Chicago condensate pumps. All the condensate is received at the boiler house by two pumps of the same type which elevate

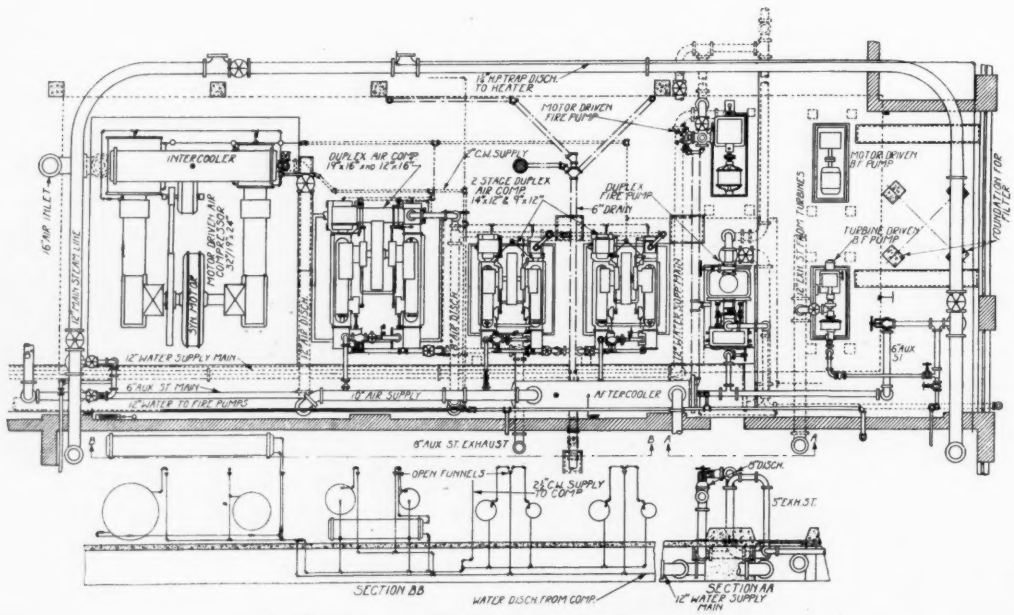


FIG. 5. PLAN OF ENGINE ROOM; COMPRESSOR ROOM

The speed of the blower motors and also of the stoker motors for each boiler is hand controlled by means of two drum controllers located on the boiler room floor at the foot of the boiler instrument panels. These instrument panels are each equipped with a well selected group of instruments, enumerated as follows: one Ashton indicating steam pressure gage; one General Electric Co. indicating and recording steam flow meter; one 3-in-1 Precision Instrument Co. draft gage; and a Tycos pyrometer for measuring flue gas temperatures.

Under normal operating conditions, the drafts maintained are 0.6 in. stack draft, 0.0 in. over the fire and 2.0 in. pressure below the grates.

The location of the instruments and controllers is such that the fireman is at all times able to maintain full control of the boiler and furnace with the least amount of physical effort.

A Custodis radial brick stack, 250 ft. high and 10 ft. in diameter produces the necessary draft above the

the water to the feed water heater, from whence the condensate flows directly to a Cochrane V-notch meter. Any surplus condensate, not needed at the moment, overflows into the water-softening tank.

All boiler make-up water is taken from the city mains and is treated in the Sorge Cochrane Hot Process Softening apparatus shown in Fig. 8. After being treated, the raw water is passed through a filter and thence through the Cochrane V-notch meter where it mixes with the condensate. The meter is located on the balcony in the engine room and has a capacity of 150,000 gal. per min.

Two boiler feed pumps are provided, one turbine driven and the other a motor driven unit. The former unit consists of a four-stage Goulds centrifugal pump capable of delivering 385 gal. per min. under a 590-ft. head, and is driven at 1755 r.p.m. by a 100-hp. 440-v. General Electric Co. motor. The turbine driven unit consists of a 90-hp. General Electric Co. steam turbine

direct connected to a four-stage Goulds centrifugal pump rated at 325 gal. per min. under a 510 ft. head.

These feed pumps are located on the compressor floor as shown in Fig. 5, and feed into a 5-in. boiler feed main arranged in the form of a loop as shown in Fig. 10. The loop arrangement, of course, insures maximum protection against interrupted service in case of accident to any part of the feed line. The 5-in. feed main is installed along the ceiling in the basement underneath the firing aisle and is arranged with eight 3-in. branch lines leading to the boilers. These 3-in. branch lines pass vertically upward through the boiler room floor, two to each boiler. There are thus two separate feed water lines to each boiler. One of these is hand regulated while the other is equipped with Copes feed water regulators and control valves. A feed water supply pipe runs to each of the three drums on each boiler.

The feed water heater is located on top of the water treating tank in the boiler room and is heated by exhaust steam from the common exhaust system. The chemical proportioner for the Sorge Cochrane treating system is located on the gallery in the engine room. The amount of chemical reagent fed is proportional to the quantity of raw water flowing into the system, and the apparatus is entirely automatic in operation.

Water for domestic purposes in the factory is heated by exhaust steam in a 42 by 168-in. closed heater located in the boiler room. Steam for this purpose is tapped off the air compressor exhaust line and the oil is removed from this steam by an 8-in. oil separator.

Steam Piping

Steam is taken from the boilers through 8-in. non-return safety boiler stop valves connecting into 8-in. boiler headers. The individual headers are installed above the boilers and connect into the main steam line through 8-in. gate valves. As may be seen by reference to Figs. 2 and 5, the main steam header is a 12-in. line installed in the form of a loop. Twelve-inch gate valves are installed in this line at a number of points for sectionalizing purposes in case of emergency. Expansion is provided for by large radius bends installed at suitable points.

In the engine room, a 6-in. auxiliary steam line branches off from the main steam header just beyond the boiler room wall. This auxiliary line passes from one side of the main steam loop to the other, and may take steam from either side. Under ordinary conditions, however, steam is delivered to this line from only one side of the loop, due to the fact that the pressure in the auxiliary line is maintained lower than the pressure in the main steam line, for which purpose a 4-in. Eclipse balanced valve is installed. The pressure in the main steam line is, of course, boiler pressure or 210 lb. The reducing valve in the auxiliary line reduces the pressure to 125 lb. for use in the steam driven air compressors.

A separate 2-in. line supplies steam at boiler pressure to the turbine driven feed pump as shown in Fig. 5.

All steam piping is exceptionally well insulated with 85 per cent magnesia covering, insuring minimum loss

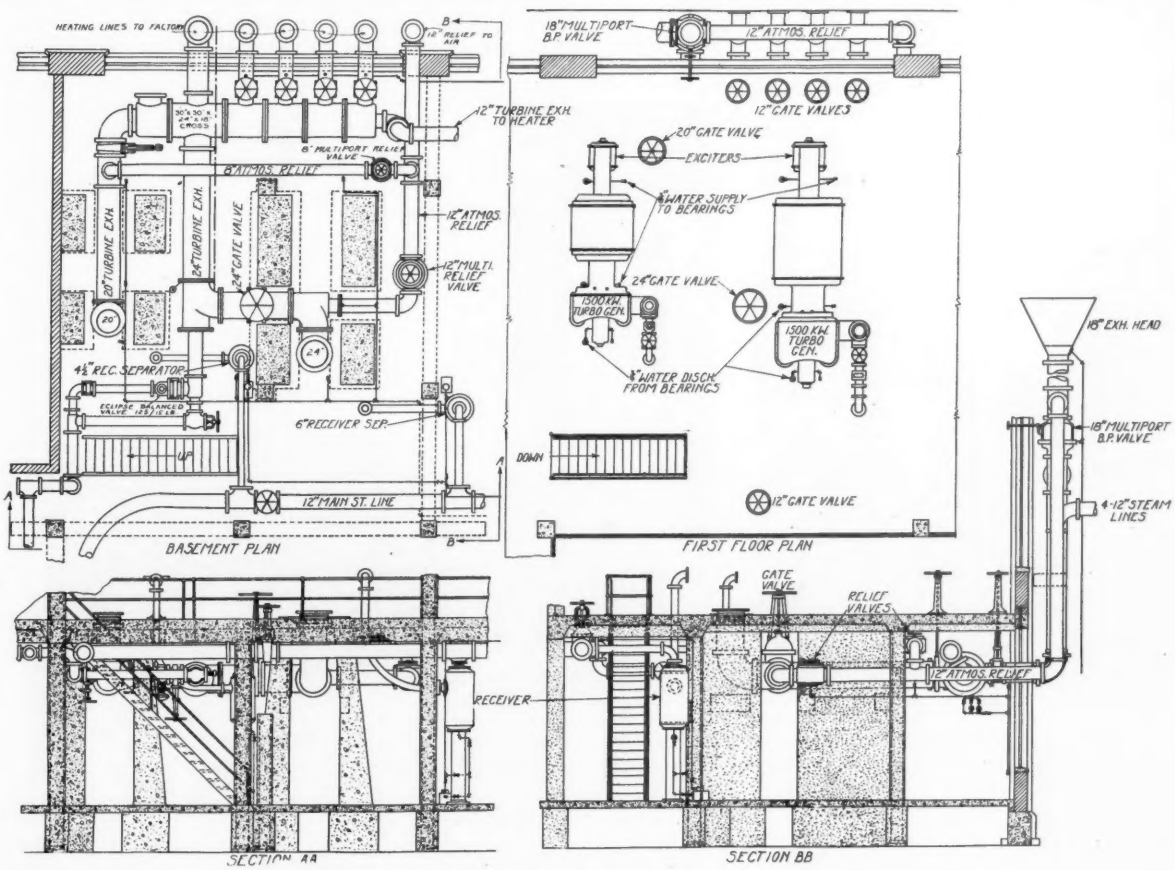


FIG. 6. DETAILS AND PIPING OF TURBO GENERATOR INSTALLATION

from radiation. Valves and fittings are all of Lunkenheimer make.

Engine Room

The engine room comprises two levels, i. e., the basement level where are located the air compressors, pumps and associated equipment, and the first floor on which are located the main turbines, switchboard and the motor generators. The first floor is arranged to form a gallery around the air compressor floor, an arrangement which provides an abundance of natural illumination throughout.

The building is of steel, concrete and brick construction. The basement floor is of concrete, while the gallery floor is laid with square tile. A glazed tile wainscoting extending about 6 ft. above the floor in all parts of the engine room improves the appearance and is easily kept clean.

a 1500-kw., 3600-r.p.m., three-stage, non-condensing, Curtis type turbine, direct connected to a 1875-kv.a. 80 per cent power factor, 440-v., three-phase, 60-cycle, generator, also with direct connected exciter.

Both of these machines are fitted with a special type of back pressure governor, which will maintain the back pressure in the exhaust mains constant. If the pressure in the exhaust mains should drop due to an increase in the use of exhaust steam, the back pressure governor will immediately cause the turbine to take more of the electrical load, thereby increasing the amount of exhaust steam to the exhaust header. If, on the other hand, the pressure in the exhaust mains should rise due to a decrease in the demand, the back pressure governor will function so as to give the turbines less load, causing a consequent reduction in the amount of exhaust steam supplied to the mains. The variation in supply of electrical energy delivered to the factory is automatically

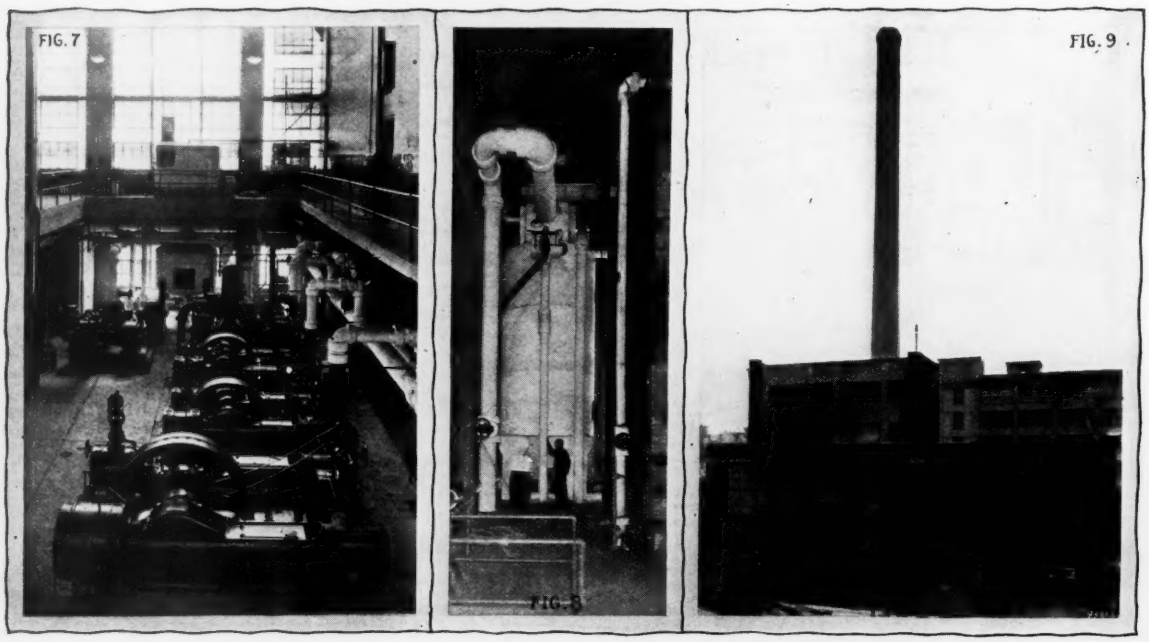


FIG. 7. GENERAL VIEW IN ENGINE ROOM, SHOWING AIR COMPRESSORS.
FIG. 8. FEED WATER SOFTENER AND HEATER. FIG. 9. EXTERIOR VIEW OF PLANT

Two Whiting traveling cranes are installed; one, a 25-T. crane over the turbines, and the other a 10-T. crane, over the air compressor floor.

Generating Equipment

Two General Electric Co. turbo-generators furnish electric current to the factory in addition to that supplied from outside sources. As stated at the beginning of this article, the primary object of installing these generators, was to provide a cheap supply of exhaust steam for heating purposes and process work. The generating units, therefore, are not large, being selected only to conform with the exhaust steam requirements of the factory.

The smaller of the two units, is a 500-kw., 3600-r.p.m. single-stage, non-condensing turbine, taking steam at 210 lb. pressure, direct connected to a 625-kv.a., 80 per cent power factor, 440-v., three-phase, 60-cycle generator with direct connected exciter. The other is

compensated for by an inverse variation in the amount of power supplied by the Niagara hydroelectric plants.

This, it must be admitted, is an ideal arrangement. The hydroelectric power can be supplied at so low a rate that an isolated steam plant, running condensing or with steam exhausting to the atmosphere, could not compete with it. The heating requirements, however, must be met, regardless of whether power is generated locally or purchased from outside sources. Hence, by proportioning the generating equipment so as to supply just the necessary quantity of exhaust steam to the heating system, and purchasing all electric power needed in excess of that generated, we arrive at the lowest possible average unit power cost.

Each turbine has its own gage board on which are mounted, a General Electric speed indicator, an Ashcroft exhaust pressure gage and an Ashcroft steam pressure gage.

The exhaust mains are arranged as shown in Fig. 6,

the turbine exhaust being connected to the mains below the floor by 20 and 24 in. corrugated expansion joints for the small and large turbines respectively. Twenty and 24-in. Chapman gate valves are installed in the exhaust line from each turbine. The two exhaust lines connect together into the heating manifold by means of a 30 by 30 by 24 by 18-in. cross, as shown in Fig. 6. An 8-in. atmospheric line from the small turbine exhaust is fitted with an 8-in. Cochrane multiport relief valve, while a 12-in. relief of the same type and make is fitted into the atmospheric line leading from the large turbine. Live steam may be admitted directly into the exhaust header through an 8-in. reducing valve from the 125-lb. steam main and for this reason an 18-in. multiport relief valve is used to protect the exhaust system piping.

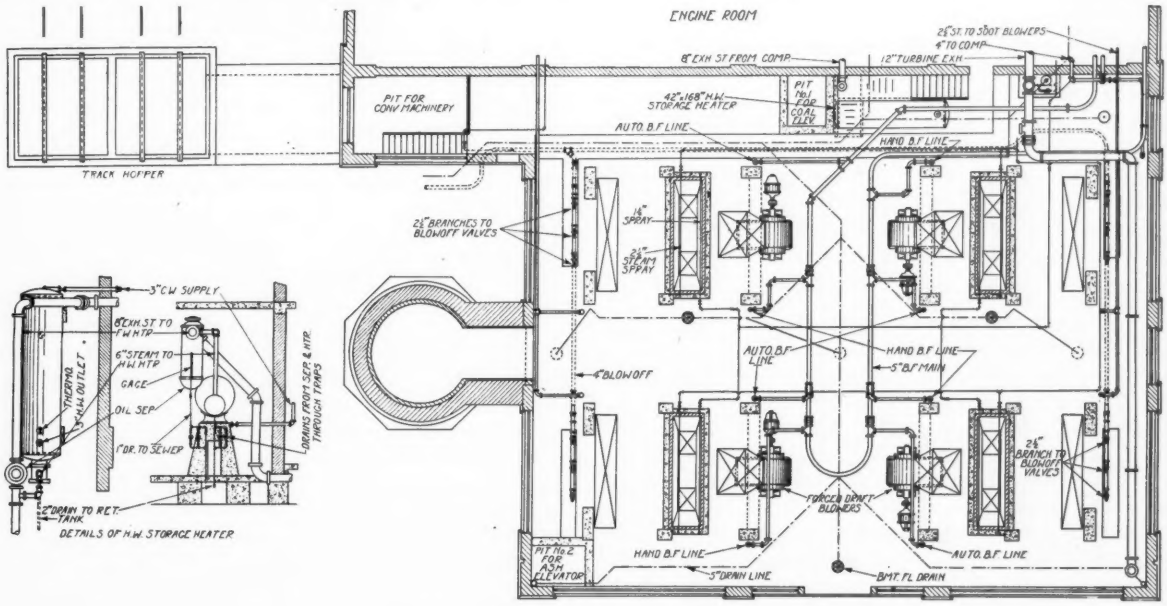


FIG. 10. BASEMENT PLAN OF BOILER ROOM

Air Compressors

Compressed air for general factory use is supplied at a pressure of 100 lb. per sq. in. by five air compressors. Three of them are steam driven units while the other two are motor driven. The steam driven units are old machines which had been used in the old factory and which were installed in the new plant, mainly for emergency purposes. Under ordinary conditions, the electrically driven units are the only ones used. Referring to Fig. 5 and beginning at the right, the compressors may be listed as follows:

Two, two-stage, duplex, Ingersoll-Rand steam driven compressors; steam cylinders 9 by 12 in. air cylinders 14 by 12 in. and 9 by 12 in. These units are supplied with steam at 125 lb. through reducing valves, and are each capable of delivering 400 cu. ft. of air per min.

One steam driven, duplex, Ingersoll-Rand compressor; steam cylinders 12 by 16 in.; air cylinders 10 by 16 in. and 12 by 16. This machine delivers 800 cu. ft. per min.

FIG. 11. SWITCHBOARD AND MOTOR GENERATORS

One Worthington, duplex, air compressor with a capacity of 3500 cu. ft. per min., size 32/19 by 24 in. This unit is equipped with Laidlaw feather valves and is direct connected to a 600-hp., 440-v., three-phase, 60-cycle, General Electric Co. synchronous motor. A 12-kw. General Electric Co. exciter is belted to the motor.

The fifth machine is located under the gallery and

is not shown on the drawing, Fig. 5. This is a Sullivan compressor rated at 1100 cu. ft. per min., and is belted to a 200-hp. General Electric Co. motor.

Air from the various compressor units is delivered through a 10 in. line to an after cooler, located under the gallery in the engine room, alongside of the boiler room wall.

Fire Protection

An adequate high pressure water supply in case of fire is provided by two fire pumps located on the compressor floor. These may be seen in the photographs and also in Fig. 5. One, is an 18 by 10 by 12-in. Knowles, Underwriters, steam driven, duplex unit, while the other is a motor driven Goulds two-stage centrifugal pump, rated at 1000 gal. per min. under a 231-ft. head; it is driven by a 100-hp. General Electric motor, at 1755 r.p.m.

Electrical Features

The main switchboard is of General Electric Co. manufacture and comprises 31, three-section panels of marine finish black slate, mounted on iron pipe framework. A synchronism indicator together with two alternating and two direct current voltmeters are mounted on a swinging bracket at the end of the switchboard. The main circuit breakers are known as Type HA-2, and are lever operated from the switchboard.

A double bus arrangement is installed in the basement, which permits current being supplied to the factory from either the power plant or the public service mains. Double throw switches are provided for this purpose. The station bus is synchronized with the public service company's bus and feeders to the factory may be thrown from one to the other at will. A reverse current relay is connected to the city lines so as to disconnect the city service in case of momentary failure of the voltage.

Two General Electric motor-generators are installed. One of these serves as an auxiliary exciter for the main generators and consists of a 50-kw., 125-v., 400-amp. direct current generator driven at 1165 r.p.m. by a 75-hp., 440-v., three-phase, 60-cycle induction motor. The other unit provides direct current for charging the storage batteries of the company's motor trucks. It consists of a 175-kw., 250-v., 637-amp. direct current generator driven at 1200 r.p.m. by a 260-hp. 440-v., three-phase, 60-cycle, synchronous motor. Both of these units are located in the gallery in front of the main switchboard and may be seen in the accompanying photographs.

Conclusion

Actual construction on this plant was started Nov. 7, 1919. W. J. Burns Co., the contractors who erected all of the various buildings of the Franklin plant, completed their part of the job Dec. 15, 1921. The building is supported on piles, over 1225 piles being driven. Electrical work and piping was installed by the Edward Joy Co., of Syracuse, N. Y. The plant was designed by S. Firestone, consulting engineer of Rochester, N. Y., although the method of solution to the power problem was put forth by J. W. Glass, of the H. H. Franklin Mfg. Co. Credit is hereby extended to the above-named engineers for assistance and privileges extended in the preparation of this article.

Comparison of Coal Costs by Charts

Charts Reduce the Bid Price of Any Coal to the Cost of One Million Heat Units. By Albert W. Deininger

POWER COSTS depend largely on fuel costs, therefore the proper method of purchasing coal is of vital importance to any coal burning power plant. The quality and cost of coal can be regulated only by purchasing the coal under specifications that describe accurately the coal desired, and yet recognize that it is a natural product varying considerably in quality, and requiring a correction of the price for allowable variations.

The purchase of coal under specifications has been discouraged to a large extent by the complexity of the specifications and the extensive calculations involved in comparing the bids and correcting the price of the coal delivered for variations in quality from the standard established by the contract.

Coal specifications usually place the coals submitted on a comparative basis by determining the cost of one million heat units for each coal. The coal containing the least ash is established as a temporary standard, and consequently the costs determined are merely comparative and without value except in awarding the contract.

Purchasers are always interested in the trend of coal costs, and naturally desire to compare the bid costs with the costs under prior contracts before making the award. Obviously that would be impossible without recalculating the latter costs using the present temporary standard as a base. Furthermore the coals delivered under prior contracts necessarily varied somewhat from the qualities described in the awards and were corrected by an arbitrary method commonly known as "Bonuses and Penalties" which probably changed the costs considerably.

The coals described in prior awards may be assumed to have been delivered at the bid price and the costs revised to the new temporary basis, but the results would be relative only because no charge would be made in the costs for the ash content up to the percentage contained in the temporary standard. The error would be serious for coals having a high percentage of ash such as are commonly used in large power plants.

The objections noted above are due to the fact that costs calculated as directed by coal specifications are relative costs which are useless for practical deductions such as the effect of the proposed coal contract on the cost of power.

Awarding Contracts on Basis of Actual Cost of Heat Units

Awarding coal contracts on the basis of the actual cost of one million heat units to the purchaser, and paying the dealers on a basis that would maintain that cost would overcome all the objections.

The apparent advantages are listed as follows:

1. The contract would always be awarded to the dealer offerings the best coal for the purchaser.

2. The price paid for coal delivered would be equitable to both the dealer and the purchaser as strictly on a value received basis.

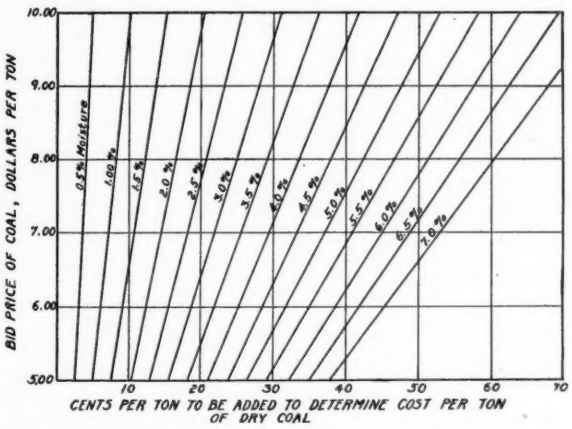


FIG. 1. CORRECTION OF COAL COST FOR MOISTURE CONTENT

3. The cost per million heat units in the coal, being actual costs to the purchaser, would permit direct comparison with previous coal costs and consequently furnish a valid means of estimating the fuel element in future power costs.

4. The method of adjusting the price of coal delivered would fix the cost of one million heat units during the life of the contract, which would make the fuel element of power cost a fixed charge for that period.

The variables that must be considered in reducing the price of a ton of coal to the cost of one million heat units are moisture, ash content, and heat value per pound of dry coal.

Moisture is foreign matter, and has been correctly treated as such. The slight loss caused by its evaporation in the furnace is negligible.

Ash content has a direct bearing on the cost of using coal, owing to the charge resulting from ash disposal. The charge will vary for different plants, but in each may be expressed as a definite charge for each one per cent ash in the coal.

The heat value per pound of dry coal must be known to calculate the cost of the different coals on a common base after each price per ton has been corrected for moisture content, and the charge for ash disposal added.

Specifications for the purchase of coal state the quality and size of the coal desired—the maximum allowable percentages of sulphur, volatile matter, and ash—the quantity desired—the quantity that may be delivered at one time—the labor necessary for delivery and storage—and any other pertinent facts. The purchaser is secured against loss due to nondelivery, or delivery of unacceptable coal by a bond proportionate to the value of the contract. The ton (2000 or 2240 lb.) is defined.

Suggested Method of Comparing Bids

It is suggested that the comparisons of the bids, and the correction of price for difference in quality of the coal delivered from that accepted, be made as stated below.

Comparison of Bids: The bids shall be reduced to the common basis of the cost of one million heat units to the purchaser as follows:

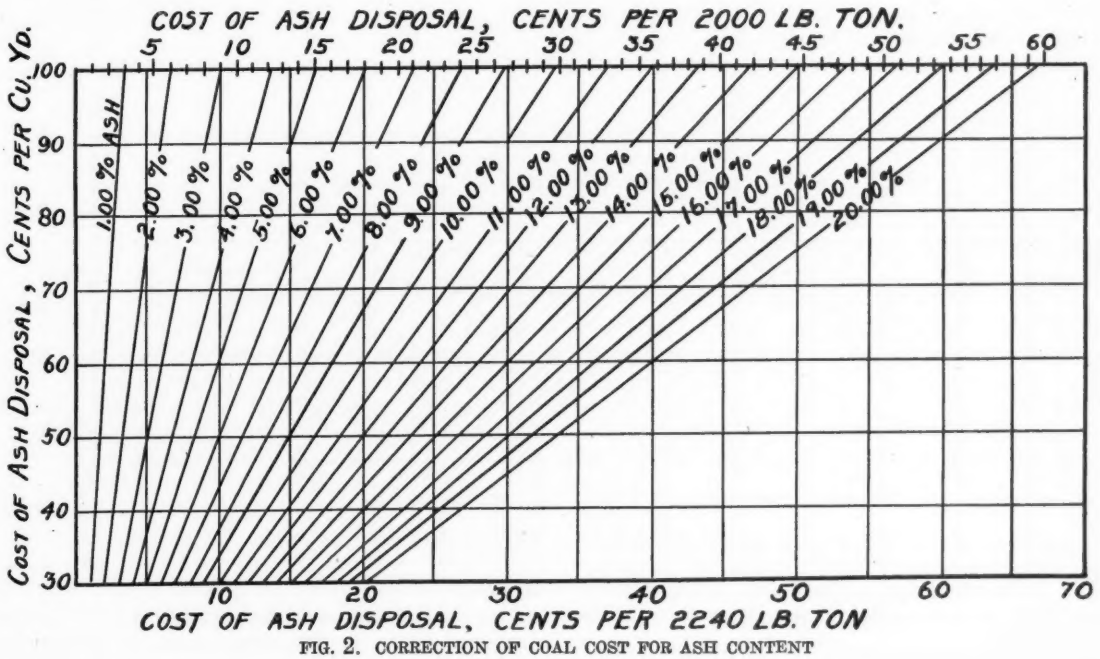


FIG. 2. CORRECTION OF COAL COST FOR ASH CONTENT

(A) The bid price shall be corrected to a dry coal basis by dividing the price bid per ton by 100 minus the percentage of moisture content, and the result multiplied by 100. The calculation shall be made to the nearest tenth of one cent.

(B) The price per ton of dry coal shall be further corrected for ash content by adding — cents for each one per cent ash in the dry coal analysis.

(C) The price resulting after correcting for mois-

ture and ash content shall be revised to express the cost of one million heat units to the purchaser by multiplying the corrected price per ton by one million (1,000,000) and dividing by the product of the heat value of one pound of dry coal and the number of pounds per ton. The cost shall be calculated to the nearest tenth of one cent.

Correction of Price: The coal delivered shall be sampled and analyzed, and the cost of one million heat units to the purchaser calculated as stated under "Comparison of Bids" using the bid price as a base. The price paid per ton of coal delivered shall be determined by multiplying the bid price per ton by the cost of one million heat units in the coal delivered, calculated with the bid price as a base, and divided by the cost of one million heat units for the coal established as a standard under the contract also calculated with the bid price of any coal to the cost of one million heat units to the purchaser.

The chart shown in Fig. 1 shows the cents per ton to be added to the bid price to revise it to a dry coal basis.

Figure 2, "Correction of Coal Cost for Ash Content," shows the cents per ton to be added for ash disposal with various costs of removal per cubic yard. In plotting the chart, it was assumed that each one per cent ash content in a 2240-lb. ton would require the disposal of 1/30 cu. yd. of refuse. The charge for each one per cent ash in the coal would therefore be 1/30 of the cost of disposing of one cubic yard of refuse. The ratio used above is an average that will usually be applicable. For a 2000-lb. ton, the ratio would be 0.03.

Figure 3, "Cost of One Million B.t.u. from Cost per Ton of Coal," shows the cost of one million heat units based on the price per ton corrected for moisture and

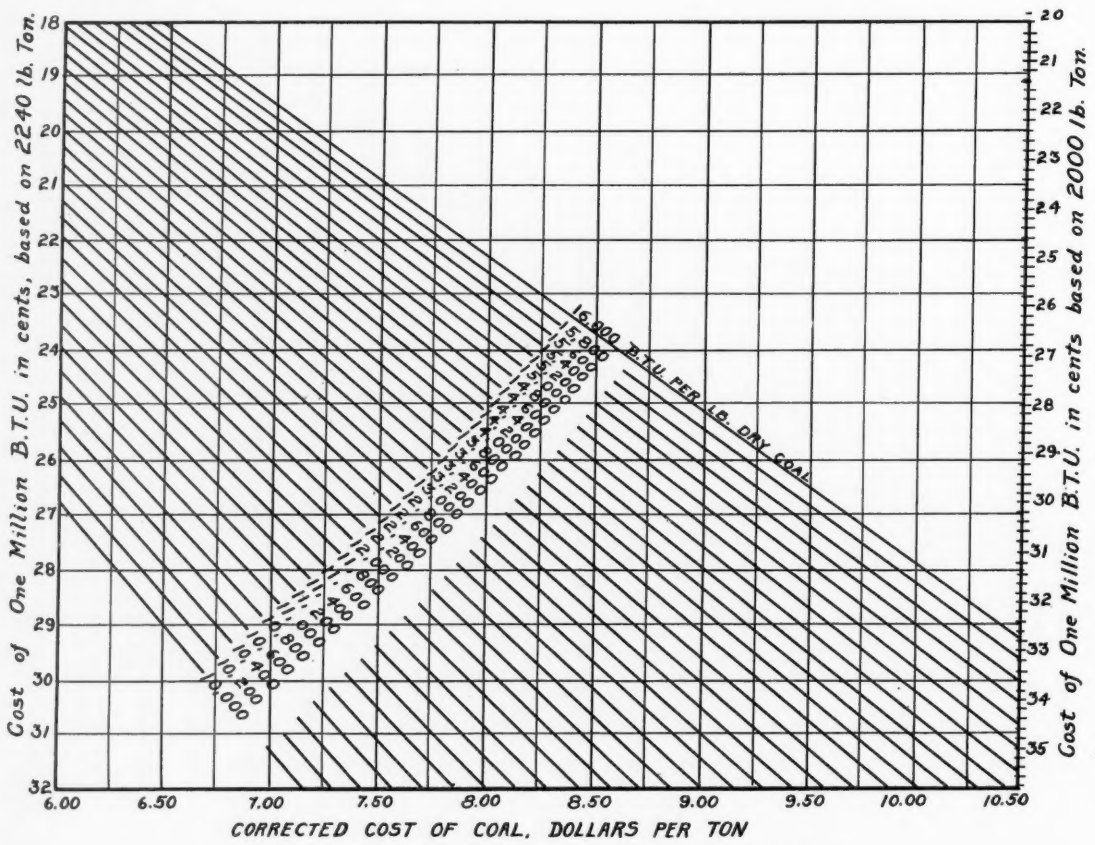


FIG. 3. COST OF ONE MILLION B.T.U. FROM COST PER TON OF COAL

as a base. The costs per million heat units referred to above shall be calculated as directed under "Comparison of Bids."

In using the foregoing methods, it is essential that the purchaser state the cost of ash disposal for each one per cent of ash in the coal, as that value is required to determine the cost of one million heat units under "Comparions of Bids," and "Correction of Price." The method of calculating the cost of ash disposal for each one per cent ash in the coal is discussed later.

Use of Charts

Three charts are sufficient to reduce the bid price ash, and the heat value per pound of dry coal. The cost can be determined by the chart to the nearest tenth of a cent which is sufficiently accurate for practical purposes.

It will be noted that all three charts are applicable to either 2000 or 2240-lb. tons.

Application of Method

Example: The following tabulation shows the application of the method and also checks the accuracy of the charts. Ash disposal is assumed to cost 75 cents per cubic yard.

Bid Accepted—	Calculated Corrections and Costs	Corrections and Costs from Charts
Moisture, 3.50 per cent.....	$0.272	$0.272
Ash, 9.50 per cent.....	0.235	0.235
B.t.u. per pound of Dry Coal, 14,300	.....	.....
Price per ton, $7.50 (2240 lb.)	8.007	8.007
Cost of 1,000,000 B.t.u.....	0.250	0.250

Coal Delivered—	Calculated Corrections and Costs	Corrections and Costs from Charts
Moisture, 4.75 per cent.....	$0.375	$0.375
Ash, 12.50 per cent.....	0.315	0.315
B.t.u. per pound of Dry Coal, 13,750	.....	.....
Price per ton, $7.50 (2240 lb.)	8.190	8.190
Cost of 1,000,000 B.t.u.....	0.266	0.266

The price paid per ton of coal delivered is then calculated by multiplying the bid price by the cost of one million heat units for the coal specified in the contract, and dividing by the cost of one million heat units for the coal delivered.

$$7.50 \times \frac{0.250}{0.266} = 7.049$$

The dealer is therefore paid $7.049 for each ton of coal delivered. That price would maintain the cost of one million heat units to the purchaser to $0.250 which was the cost calculated from the bid.

Anyone who has compared coal bids and corrected the price of coal for variations in quality will appreciate the simplicity of the method, the accuracy of the results obtained, and the possibility of direct comparison with prior coal costs as a means of estimating the effects of the proposed contract.

Other Uses of Charts

Obviously the charts may be used for other purposes than awarding contracts and adjusting prices. For example, assume a plant with boilers having sufficient grate area draft to use any one of the following coals:

	Pea	No. 1 Buckwheat	No. 2 Buckwheat	Rice
Moisture per cent..	3.00	4.50	6.00	7.00
Ash per cent	14.00	16.00	18.00	20.00
B.t.u. per Pound of Dry Coal	13,500	12,500	11,500	11,000
Price per ton (2240 lb.)	$9.00	$8.00	$7.00	$6.00

The above analyses are assumed. The increase in ash and moisture, also the decrease in heat value in the smaller sizes represent a general tendency. Individual analysis will vary considerably from those noted.

The cost per million heat units for the above coals were calculated and are listed in the following tabulation. The charts showed the same costs. Cost of ash disposal was assumed as $0.75 per cu. yd.

	Pea	No. 1 Buck-wheat	No. 2 Buck-wheat	Rice
Bid price	$9.00	$8.00	$7.00	$6.00
Correction for moisture	0.278	0.377	0.446	0.452
Correction for ash....	0.35	0.40	0.45	0.50
Corrected price per ton	9.628	8.777	7.896	6.952
Cost of 1,000,000 B.t.u.	0.319	0.314	0.307	0.282

The cost of No. 2 Buckwheat, either calculated or determined from the charts, is $0.3065 per million heat units; but as the cost is calculated to the nearest tenth of a cent, $0.307 is used. The error is one-sixth of one per cent. An error of one-tenth of a cent would amount to one-third of one per cent, which is less than the probable error in the coal analysis.

The Rice coal is evidently the cheapest for the plant considered. With price adjustments calculated as outlined previously, the contract could be awarded without question, as the cost per million heat units would be maintained for the duration of the contract if the cost of ash disposal were unchanged. To eliminate that possibility, it is suggested that ash disposal contracts be made to cover the same periods as the coal contracts.

Fuel Conservation in Industrial Power Plants

Instruments Are the Eyes of a Plant. A Saving of at Least 10 Per Cent in Fuel Consumption Can be Effected by Using These Eyes. By David Moffat Myers

Among the most vital lessons taught by the great European war were those which are applicable in industrial fields, but which unfortunately seem to have been all too soon forgotten or disregarded. The explanation, however, is simple. It was only natural that, after the high-pressure effort occasioned by the war, there should be a general let-down and relaxation along industrial and other lines. Business was such that prices were high and money was easily made. Why should plant owners worry about costs of steam, heat, and power when excellent profits could be made without worrying?

The war and war measures have now become a part of history. True, but a new, and tremendously crucial situation now confronts us. Industry itself is most certainly threatened. It must be saved, and to that end the right methods must be quickly, widely, and intelligently adopted.

There are only two methods whereby steam and power can be produced at lower cost. The first is, improvement in the design or equipment of a plant. The second is, improvement in the method of operation. Even if equipment changes appear to entail unwarranted expense, under present-day conditions, at least there is no reason why improved methods of operation cannot be successfully applied, with resultant benefit to each individual industry, and decided advantage to business as a whole.

I recommend, therefore, that a general movement be started to bring about economies in methods of operation.

If there be any who are skeptical as to the efficacy of such procedure, let them note well the fact that dur-

ing the war, when it was not possible to obtain new or improved power equipment, a saving of twenty-five million tons of coal throughout this country was effected annually by means of the second method alone—by operating improvements, by securing the greatest possible efficiency from the equipment which was at hand. No better illustration could be had, to show real economy on the part both of the individual plant owner and of the nation as a whole, in whose behalf the plan was evolved and put into practice. Twenty-five million tons! A large figure—and, at that, merely the beginnings had been made when the end of the war came and these large-scale national measures were discontinued.

One is all the more impressed with the possibilities in this plan when it is realized that, even under the rush conditions accompanying the war measures, when the saving of labor and fuel was big-scale but not thorough, fuel savings of from 10 per cent to 30 per cent were reported by plant owners all over the country. As an illustration, one interesting case in point may be cited here. In a certain plant, where no change of equipment was made, half the total number of boilers were shut down, 50 per cent more steam was made with the same coal consumption as formerly, and the evaporation was increased from 6 to 9 lb. per lb. of fuel.

If, then, such savings as have been cited could be accomplished even during the rush of the war, still greater economies can be effected at this period when thorough attention can be given to each individual plant. Certainly this is the time, of all times, when such economies should be planned and accomplished. There is hardly an industrial power plant in the country which could not easily make a saving of 10 to 30 per cent without change in boiler or engine room, provided an exact knowledge of existing performance is available. This definite knowledge is the first requirement, and absolutely essential.

The question is, how can this definite knowledge be obtained? An equipment of proper recording instruments, selected according to local conditions, and used regularly and intelligently, will give the desired information.

The Value of Instruments

The first step, therefore, is to determine by means of an adequate outfit of instruments for the purpose, whether the highest return possible is being secured from the existing equipment. *Unless such instruments are supplied by the management, the plant is without eyes and its operation is blind.*

On the other hand, the right equipment of instruments makes it possible for the management to know, from day to day, the actual results being obtained, the plant's efficiency under daily operating conditions. The instruments will show any combustion troubles; whether the coal is the best for furnaces and steaming conditions; what the steam production is, and where the steam "goes to"; whether the quality of coal that is being paid for is being obtained; whether any of the boilers are failing to carry efficiently their proportion of the load.

One item of importance to determine is the equivalent evaporation per pound of coal. To secure accurate data in this respect, it is necessary to measure continuously the weight of feed water or steam, and the weight of coal, and to ascertain steam pressure and feedwater temperature. In addition, occasional B.t.u. determinations of the coal should be made. If this practice is followed it will enable the management to know two very important things:

1. The actual efficiency of the plant itself.
2. How the results obtained compare with standard efficiencies secured from the same kind of coal and equipment. The instruments used to make all these determinations tell *what efficiency you are securing.*

Another class of instruments is used when you have found that your efficiency actually is too low. These instruments of the second type, or class, *tell why the efficiency is low.* In other words, they determine the causes of the waste, and, this being done, you will be able to check all that is preventable. Among the most important of these instruments are flue pyrometers and the apparatus for flue-gas analyses. These indicate the one greatest loss in boiler plant operation, the (dry gas) chimney loss which may run as high as 40 per cent of the total fuel. Draft gages also play an important part in determining the "why" of losses. Sometimes in an "efficient" plant the amount of air allowed to leak through settings will be as great as that which passes through the grates. It will be found decidedly worth while to apply to the outside surface of all brick set boilers a thorough plastic air-tight coating to prevent air leakage, and to give careful attention to all other connections where such leakage is liable to occur—for example, header and other connections, and clean-out doors and their frames.

An investment in recording instruments pays good dividends. These instruments must, of course, be selected carefully and with good judgment, and records must be kept with the greatest possible simplicity that is conducive to the securing of all essential data. It may seem surprising—but it is true—that, irrespective of the design of the plant, one quarter of the coal cost may be wasted through poor methods of operating, alone; and that, at a very conservative estimate in the average plant, 10 per cent of the fuel consumption may be saved by means of an intelligent application of the methods already discussed. Even a simple change in the method of firing will often effect an annual saving of thousands of dollars.

Most plants are being run blind. Every plant must be equipped with eyes, in order to see where the waste occurs and to be able to check it and prevent its recurrence. The required instruments are so simple, and the results from their use pay such big dividends. that it is surprising how many owners fail to avail themselves of the economies directly within their reach.

It is a long time since safety valves and steam gages could be considered adequate and efficient equipment for an up-to-date plant. For each plant, with its individual conditions and its own particular layout, the proper instruments should be prescribed. Then, this having been done, the firemen can easily interpret the readings and be in a position to know whether the results obtained are what they should be. If they are not, the firing and the draft controls can be corrected and adjusted to bring about the utmost efficiency in relation to required capacity. In other words, unnecessary losses, which would remain invisible except for the use of these instruments, are revealed.

Improvement in Design

Emphasis has been laid on the fact that the economies discussed can be effected through improvements in operation alone. It is important to realize at this point, however, that such improvements constitute an intelligible and essential preliminary to improvements in design as well. These things will have to be done before improvements in design can be made intelligently. Why not do them now and secure their dividends immediately? When the ebb tide of business changes to flood —as it soon and inevitably will change—and executives are working under great pressure, it will be a poor time to have to plan for economy of heat and power. The new order of things will not be like the old—wasteful plants will not be able to make a profit.

Plant owners and managers should know how to utilize in the most modern and efficient way the waste heat from exhaust steam and from other sources. Local conditions and requirements must be carefully taken into account if all improvements are to bring the best possible result. Owners and managers should know that there is almost as much heat in exhaust steam as there is in live steam coming directly from the boilers. It must be definitely ascertained in the power plant of each individual factory or mill, whether it will cost less to produce power within the plant itself or to purchase it from outside. This problem bears a vital relation to heating and process requirements. Losses connected with the application and distribution of electrical energy and steam must be stopped and waste in connection with their generation must be checked. All industries should clearly comprehend that practically 100 per cent of the energy in exhaust steam can be reclaimed if applied in process work or the heating of buildings; but only 10 per cent to 20 per cent of this energy is recovered by connecting a prime mover to a condenser. It must be definitely determined in each manufacturing plant, what heating system, boilers, furnaces, prime movers, and fuels will be most conducive to the greatest possible economy under its particular set of local conditions.

It is important to remember that much time is required to gather the necessary preliminary information in any plant, and still more time must be allowed for the procuring and installing of the equipment which economy demands.—General Electric Review.

Effect of Long Suction Line on Pump Performance

Increased Friction Loss in Old Pipe Line Causes Decrease in Capacity of Pumping System. By W. A. Shmidheiser

RECENTLY my attention was called to the action of a fire pump which behaved rather badly when under load. The pump was a 14 by 10 by 10-in. Worthington duplex steam pump, rated at 660 g.p.m. at 51 r.p.m. Steam pressure averaged 93 lb. while the exhaust was atmospheric. The suction line to this pump was of 6-in. standard pipe, 725 ft. long, and the pressure at the beginning of this line, or 725 ft. from the pump, was 15 lb. per sq. in. when the pump was not working. An examination of the pump showed it to be in excellent state of repair.

In order to obtain data regarding the action of the pump while working and thus determine the cause of the trouble, all outlets from the line were closed and suction and pressure gages attached to the line at points

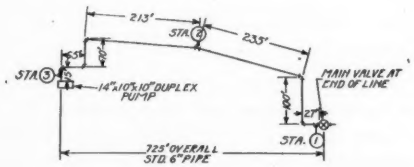


FIG. 1. DIAGRAM ILLUSTRATING ARRANGEMENT OF PUMP AND SUCTION LINE

indicated by stations 1, 2 and 3, as shown by Fig. 1. All gages used were calibrated before using.

With the pump not running, two sets of gage readings at an interval of 5 min. were taken. The gages indicated the same pressure throughout the line, which established the fact that the line was tight.

The pump was now operated, at various speeds, slowly at first and gradually increasing the speed until the pump refused to function properly. Readings on all the gages were taken at each speed of the pump and the amount of water discharged was measured by means of an impact tube and nozzles.

TABLE SHOWING RESULTS OF TEST

Test on 14 x 10 x 10 in. Worthington Duplex Steam Pump

Reading No.	Revolutions.	Cal. by Diaphragm	Cal. by Measurement	Slip %	Discharge Pres.	Pres. on Pump Suction Sta. #3	Pres. at valve Box Sta. #2	Pres. at Gage Sta. #1	Total Pres. Drop	Drop between 1 & 2	Drop between 2 & 3	Distance from Pipe End at which Atmos. Pres. occurs.
1	0	0	0	0	15	15	15	15	0	0	0	
2	0	0	0	0	15	15	15	15	0	0	0	
3	13	176	60	66	7.0	12.5	14.2	14.5	2.5	.5	.3	
4	19	288	140	48.7	15	9.5	12.5	14.5	4.5	1.7	3.0	
5	31	299	200	33.1	19	9.5	12.0	14.0	4.5	2.0	2.5	
6	26	265	256	27.5	22	8.0	10.5	14.0	6.0	3.5	4.7	
7	30	407	296	27.5	25	1.0	8.5	14.0	13.0	5.5	6.4	
8	32	435	304	30.5	40	- .90	7.1	14.0	16.0	6.9	8.1	681
9	34	462	332	28.2	43	- 2.46	6.5	13.0	16.5	7.5	9.0	618
10	38	515	380	26.4	55	- 5.62	4.0	13.0	20.4	9.0	10.4	500
11	40	545	394	27.4	60	- 9.00	2.5	13.0	23.1	10.5	11.6	441
12	45	612	439	28.0	70	-12.52	0	13.0	25.5	13.0	12.5	363

Gallons per Revolution = 13.6 (Theoretical)

The results obtained are contained in the accompanying table and are shown graphically in Figs. 2 and 3.

An inspection of Fig. 2 indicates that when the pump was not in operation, the pressure throughout the line and on the suction of the pump was 15 lb. per sq. in. As the speed of the pump increased, the pressure at the pump suction rapidly decreased until at approximately 32 revolutions the pressure became atmospheric. A further increase in pump speed changed the pressure from positive to negative until at 42 revolutions (70 ft. per min. piston speed) and a discharge of 420 gal. per min., the negative pressure at the pump suction was 10½ lb. Any other combinations of pressure at pump suction when compared to gallons delivered, or pump speed, may be obtained from this curve.

Figure 3 shows the per cent slip and discharge pressure attained at various rates of discharge of the pump, while the curve marked "Atmospheric Pressure" shows the distance from the end of the pipe at which the change from positive to negative pressure occurs at various discharge rates.

The highest pressure attainable was 70 lb. at 435 g.p.m. and at this capacity the pump pounded badly.

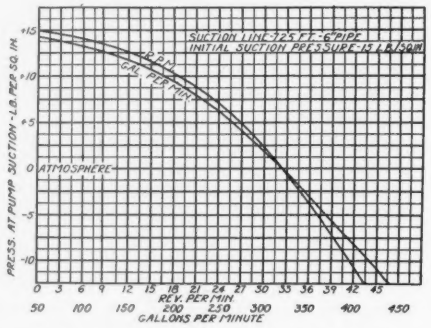


FIG. 2. REDUCTION IN SUCTION PRESSURE DUE TO PUMPING

The lowest slip occurred at about 317 g.p.m. which, from an examination of Fig. 2, indicates that at this rate the pressure on the pump suction was atmospheric. This slip is high, however, but may be due to the fact that the piston speed of the pump at this rate is but 62 per cent of the normal speed. Beyond this point, the slip increases, due to negative suction pressure.

An examination of the atmospheric pressure curve shows that when the maximum amount of water was flowing the change from positive to negative pressure occurred at a distance of 363 ft. from the end of the line, or at the point midway between the pump and end of line; while at lesser flows the point moved closer to the pump, until at 317 g.p.m. the change in pressure took place at the suction flange of the pump.

In conclusion, it might be mentioned that the suction line has been in service at least 20 yr. The water handled is very dirty and at certain times of the year contains much suspended matter. It is realized that the results obtained show a high friction loss, but that the loss is due to friction and not to an obstruction in one section of the pipe, is indicated by the general agreement of pressure drops in each half of the line as shown by columns 11 and 12, in the table of results.

The average amount by which the drop in pressure between stations 2 and 3 exceeds the drop between 1 and 2 is approximately 1 lb. and this difference is easily accounted for by the greater number of fittings in the lower section of the line, especially where the piping is connected to the pump.

The important fact developed by the investigation is that where piping is to remain in service for a considerable number of years, the fact of increased friction due to interior surface and reduction of area should be carefully considered, as a pipe which may be satisfactory when new will fail to supply the requisite amount of water after some years of service. In this case, when new, the pipe probably supplied sufficient

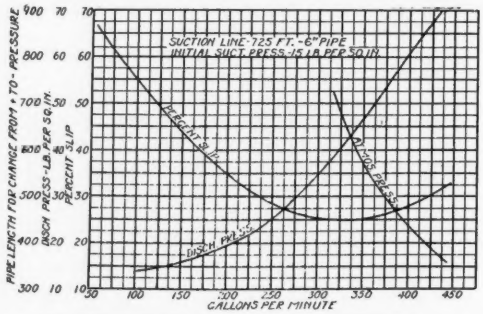

SUCTION LINE-725 FT.-6" PIPE
INITIAL SUCT. PRESS.-15 LB. PER SQ.IN.
PIPE LENGTH FOR CHANGE FROM + TO - PRESSURE
PERCENT SLIP
DISCH. PRESS.
GALLONS PER MINUTE

FIG. 3. PER CENT SLIP, DISCHARGE PRESSURE, AND POINT OF CHANGE FROM POSITIVE TO NEGATIVE IN SUCTION LINE FOR VARIOUS DISCHARGE RATES

water, as computations indicate that at 660 g.p.m. a drop of approximately 16 lb. might be expected. As the case now stands, in order to work the pump to capacity, a larger line must be provided, which will entail considerable expense. This might have been avoided if an 8-in. line had been placed originally.

Diesel Engines*

General Analysis—Four Cycle Air Injection Type

THE EXTRAORDINARY inroads made by the Diesel engine during the last decade into fields so successfully occupied by steam power, suggests that there must be some very vital reason. The reason is not hard to find, for Diesel engines consume about one-third as much fuel as steam engines of corresponding power. Furthermore, they make no use of the carburetors and ignition systems characteristic of other types of internal combustion engines. In the ideal and most highly developed Diesel engine, any grade of liquid fuel from kerosene to tar oil can be used since it is injected directly into a cylinder when the upward stroke of the piston has compressed pure air to such a pressure and temperature that the fuel burns as it is sprayed in. Many types of Diesels, however, are not sufficiently developed to burn the heaviest grades of oil. It is a characteristic difference between steam and Diesel units that the efficiency of the former, particularly steam turbines, increases materially with the size of the unit, while with Diesels the size has little effect on efficiency. Thus there is a tendency in stationary service to segregate steam power in large units which tendency does not exist with Diesel engines. Even a 45,000-hp. steam turbine unit consumes 85 per cent more fuel per horsepower developed than a Diesel as small as 300 hp.

Disadvantages of Diesel Engines

THE ONE serious drawback to the present day Diesel is its high first cost. Generally speaking a Diesel engine costs almost twice as much per horsepower as the corresponding steam engine with its boilers and auxiliaries. This means that the relative cost of power between a

*Abstract of an article appearing in Lubrication which is published by the Texas Company.

Diesel and a corresponding steam engine depends on the number of hours of service secured per year, for if power is required only occasionally the interest and depreciation which run on regardless of operating or idle time, will more than outweigh any advantages resulting from lower fuel consumption. Thus, in order to show the greatest advantages of the Diesel engine it should be run in as continuous service as possible.

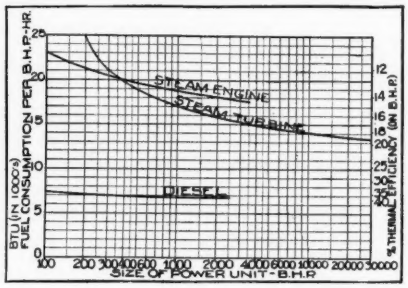


FIG. 1

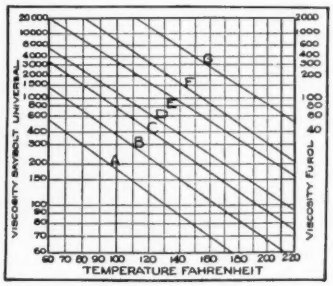


FIG. 2

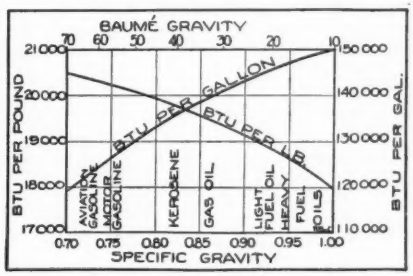
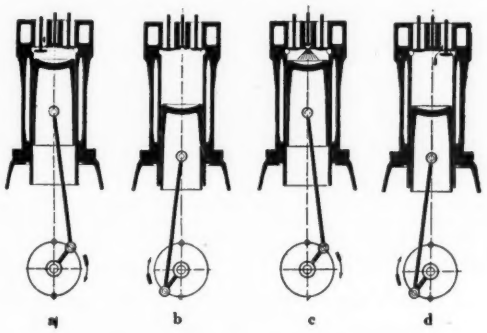


FIG. 3

FIG. 1. VARIATION OF PROBABLE EFFICIENCIES OF STEAM AND DIESEL ENGINES WITH SIZE OF UNIT. FIG. 2. EFFECT OF TEMPERATURE ON THE VISCOSITY OF TYPICAL AMERICAN FUEL OILS RANGING FROM ABOUT 25 DEG. TO 14 DEG. BAUME. FIG. 3. RELATION BETWEEN HEAT VALUE PER POUND AND PER GALLON OF REPRESENTATIVE AMERICAN PETROLEUM FUELS

Fears for lack of reliability can be dismissed, for when trouble has occurred in the past it has been due to imperfections in mechanical design which had nothing to do with the fundamental features of Diesel engines.



(a) First stroke (suction), piston travels down; admission valve open; cylinder is being filled with *pure* air.
(b) Second stroke (compression), piston travels up; all valves closed; air in cylinder is being compressed to about 500 pounds per square inch, which heats it to about 1000° F.
(c) Third stroke (power), piston travels down; fuel valve opens at top dead-center, and sprays fuel into the compressed air which is hot enough to burn it as fast as admitted. There is no explosion, and no rise in pressure. Fuel valve closes after about 1/10 of stroke; gases expand.
(d) Fourth stroke (exhaust), piston travels up; burnt gases are expelled from cylinder thru the open exhaust valve.

FIG. 4. SEPARATE STEPS OF FOUR CYCLE TYPE ENGINE

In many engines the imperfections were entirely eliminated as the designers became more experienced.

Fuel Consumption

Fuel economy can be considered from two standpoints:

1. Consumption.
2. Cost.

In discussing the fuel consumption of Diesel engines, comparison should be made with other oil-burning installations, as a consideration of coal involves many other factors, such as transportation, storage, bunker space, etc., which only complicate the discussion. Diesel engine advocates show that this form of internal combustion engine consumes about one-third of the fuel which would be required for steam producing outfits of same output using oil as a fuel. While fuel consumption may not be the whole story, nevertheless the claims of Diesel engine manufacturers have sufficient backing to merit very serious consideration by fuel economists.

Practically all American fuel oils are derived from crude petroleum by the removal of some of the lighter products—"topped." Fuel oils are usually graded either according to the specific gravity or the Baume scale, though there is a rational tendency to grade according to viscosity. Though viscosity roughly increases with specific gravity, oils of same gravities from different localities may have different viscosities. This makes it impossible to determine either viscosity or volatility by gravity unless the source is known. All grades of fuel oil from petroleum have ignition temperatures low enough to give no trouble when used as boiler or Diesel fuel. Fuels of high viscosity, however, are so difficult to handle because of their sluggish flow to and through piping and the difficulty of atomizing them that they are not in as great demand as those grades of lower viscosity, and are consequently available at lower cost. As is well known, the viscosity of all oils falls as they are heated, which makes it possible to use even the most viscous oils if they are sufficiently heated; but if through accident or carelessness the pipes conveying them, particularly to the

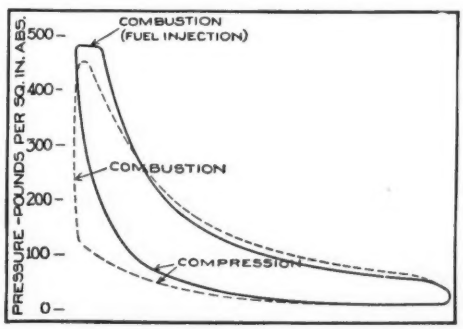


FIG. 5. COMPARISON OF INDICATOR CARDS OF A DIESEL ENGINE (SOLID LINE) AND A LIBERTY AIRPLANE ENGINE, OTTO CYCLE (DOTTED LINE)

pumps, are allowed to cool, it is a disagreeable task to "thaw" them out again.

It is considered good practice with the less viscous, and exceedingly desirable with the more viscous grades which require heating, to stop Diesel engines on kerosene or similar oil so that starting from cold will be easy. As soon as the engine is warm after starting, it may be switched over to fuel oil again. Two other decided advantages result from this practice: 1. The kerosene washes out the fuel system and spray nozzles, thus keeping them from gumming. 2. Corrosion is lessened. Fuel oils sometimes contain sufficient sulphur to form sulphuric acid in the exhaust due to the water present. As long as the gases are hot enough to keep water vapor (a product of combustion) from condensing, no harm will result, but when an engine is stopped and allowed to cool, water will collect on the cool metal and the acid formed will cause serious pitting. This is, of course, avoided by stopping and starting with an oil

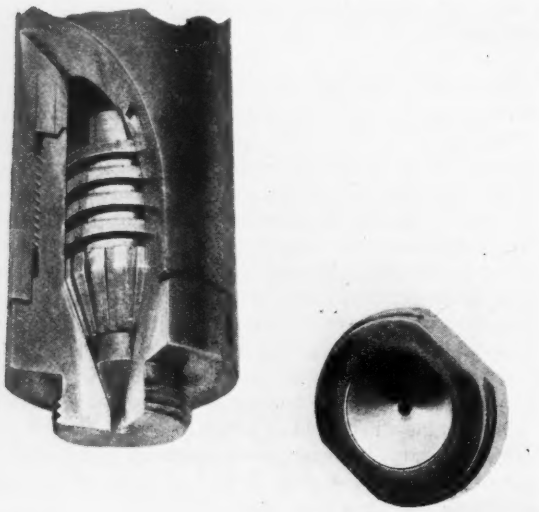


FIG. 6. A SECTION OF THE LOWER PART OF A WIDELY USED TYPE OF DIESEL SPRAY VALVE

like kerosene. This procedure makes possible the use of a fuel oil fairly high in sulphur and low in cost.

Cost of Fuels

All grades of fuel from crude oil have about the same heat value or available energy per pound, the heaviest fuel oil having only about 12 per cent less than aviation gasoline, as shown in Fig. 3. On the other hand, the greater density of the heavier oils results in a materially higher heat value when based on volume, and this is the customary method of selling. The more volatile (and less viscous) fuels, however, are easier to use, and in the case of many engines now built, are the only ones that can be used. The result is that in commercial practice there is found a greater demand and consequently a higher price for these fuels. Most types of internal combustion engines, though not all, can be adapted to burn a light gasoline; kerosene engines of the carburetor type are still in the development stage; the so-called semi- and super-Diesel engines can make use of still heavier fuels, but no internal combustion engine other than the highly developed Diesel can at present make use of the heavier fuels which represent a large proportion of the bulk of the output from crude oil. The result of this balance between supply and demand is a market price for fuel oil about one-tenth of that for gasoline in bulk.

The Four-Cycle Type

The separate steps of the four-cycle type are shown diagrammatically in Fig. 4, from which it is seen that four complete strokes of the piston from one end of the cylinder to the other are necessary in the operation of a complete working cycle. To be more exact, it should be called the four-stroke cycle, but common usage has abbreviated it to the term "four-cycle." In the Diesel engine, no fuel is mixed with the air drawn into the cylinder until the beginning of the power stroke, when it is sprayed as a very fine mist into the air and burns as admitted because of the high temperature of the air due to its compression.

Compression, therefore, must be great enough to cause ignition of the liquid fuel when it is injected, which means a pressure of at least 450 to 500 lb. per sq. in. In the automobile engine (Otto engine) compression must not be great enough to ignite the fuel mixed with the air, and consequently is limited, as far as pre-ignition is concerned, to 100—150 lb. per sq. in. This is a very important difference, because the thermal efficiency, and the power developed from a given quantity of fuel increase for both types of engine as the compression is raised. For a given compression, the Otto engine is theoretically more efficient than the Diesel, and the superiority associated with the Diesel is due to the fact that it uses a much higher compression. The higher efficiency of the Otto for a given compression is due to the fact that combustion occurs so much more rapidly than with the Diesel, causing a great rise in pressure, while with the latter type there is practically no rise in pressure. The result is that in spite of the high compression of Diesel engines, the maximum pressure during the cycle is usually but little higher than is frequently obtained in high compression Otto types, as airplane and racing engines. A comparison is made of indicator cards from these two engine types in Fig. 5.

Another point of contrast between the Diesel and Otto types of engines is the means by which regulation is accomplished for light loads. As the Otto can operate only with such quantity of fuel mixed with air as will make an explosive mixture, and since air and fuel mixtures explode only between very narrow percentage limits, it is not possible to regulate its power output by varying the quantity of fuel used without varying the quantity of air also. Thus the compression and also the thermal efficiency is lowered at fractional loads. This is not the case with the Diesel since the quantity of fuel used can be reduced as far as desired without affecting the air or the compression, with the result that at light loads the Diesel engine does not suffer as great a proportionate increase of fuel consumption as the Otto.

Fuel Injection

Fuel injection is accomplished by atomizing with compressed air much in the manner of medicinal atomiz-

ers, and until recently this was the only successful method. A very fine "pulverization" of the fuel is absolutely essential for quick smokeless combustion, and is the crux of successful Diesel operation. The injection air pressure must be several hundred pounds above that in the cylinder at the moment of injection, and consequently ranges from 700 to 1000 lb. per sq. in. The actual pressure should be varied if the speed or load vary materially, and while adjustment is often made by hand, several very successful means have been used by which this is done automatically. If the pressure is too low the exhaust is smoky, while if too high the engine "knocks" as a result of a rise in the cylinder pressure due to the explosive effect of injecting the fuel too rapidly. Smoking sometimes results from too low a compression pressure, due to leaky cylinder valves or bad piston rings.

In Fig. 6 is shown a sectional assembly of the lower part of a typical fuel valve. The needle is ground to its seat and opens the valve by being lifted upward. The space above the rings is continually under the pressure of the injection air. At proper intervals, a measured quantity of fuel oil is forced through the space in the side of the valve against the air pressure, and when the valve needle is lifted at the moment of injection, air mixed with the oil present is forced through the fine holes in the perforated rings and after traversing these irregular paths the mixture is so complete and divided that when it enters the cylinder the expansion of the air sprays the fuel as desired. Adjustment can be made for different oils by changing the number of perforated rings.

The vital importance of the fuel valves, together with their number of minute holes and passages emphasize the desirability of taking precautions to see that there is no solid sediment in the fuel oil, and of using kerosene just before stopping so as to wash out any tarry substances which might gum them. It must be remembered that the expansion of the injection air with the fuel has a cooling effect, which requires a higher cylinder compression than would otherwise be needed in order that the resulting temperature will be sufficiently high for ignition.

Air Compressors

The compressor which supplies the injection air is one of the most important and vital auxiliaries of a Diesel engine, and one which requires particular attention in order to be sure that it functions properly. The amount of air handled by the compressor is about 5 per cent of the total capacity of the cylinders, and in compressing it to approximately 1000 lb. per sq. in. almost 10 per cent of the power developed by the engine is expended. Compressing and handling air at such very high pressures is a formidable matter. If even one of the small steel tubes carrying the compressed air to an injection valve fails, the amount of energy liberated will cause an explosive effect that may badly injure anyone close at hand. Copper tubing is recommended by some engineers who state that in case of failure, on account of its ductility it will split and not fly to pieces as does steel.

In standard practice the compressor is direct-driven at the end of the engine, and divides the work of compression between three stages, with the water-cooled "receivers" or "intercoolers" between the stages. The cylinders, which are water-cooled, are usually provided with some form of very light automatic valve.

Compressor Lubrication

One of the secrets of successful compressor operation is its lubrication, and it cannot be over-emphasized that the least possible quantity of oil must be used. Any excess will carbonize because of the temperatures to which it is exposed. This carbonaceous matter is sticky in the early stage of its formation, which gives it a tendency to adhere to the piston rings, valves, receivers, and may be carried even to the fuel valve parts. In its later stages, the carbon forms a hard solid that interferes with the operation of the compressor. Unfortunately there is no oil which will not deposit some carbon, but there is a surprising difference in the quantity of carbon deposited by different oils. Consequently not only must oil be selected with care, but particular attention must be paid to prevent the use of more oil than is necessary.

Each cylinder is supplied with a mechanical lubricator which feeds small, measured quantities of new oil to these parts. It has been found that only a drop or two a minute to the first two stages is sufficient, the third stage being abundantly supplied by oil carried up from the second. The safe course to follow in regulating the quantity of oil used is to remove the valves from time to time and examine the cylinder walls. They must have enough oil to feel oily, but no more.

A knowledge of the heat due to compression has caused an unfortunate confusion in the minds of some operators as to the interpretation of the flash points of the lubricating oils for air compressors. Flash point readings are of value only in indicating the relative volatility of different oils, and are not definite temperatures at which they "boil" or go completely into vapor corresponding to the boiling point of water. With oils of higher volatility, a slightly greater quantity will be required to keep a film on the cylinder walls, and consequently a greater quantity will be carried into the receiver in the form of vapor. This can do no harm whatever because an oil with a flash of over 300 deg. F. will never be carried into the air in such quantities as even to approach a combustible mixture. A combustible mixture would necessitate the presence of almost one gallon of oil to be vaporized in each thousand cubic feet of free air or about each hundred feet of compressed air. On the other hand, the oils which leave unusually low carbon deposits have lower flash points than many which leave large deposits. Hence the balance must be drawn between getting a moderate amount of vapor and very little carbon in the air or appreciable carbon and only a little vapor.

It is very desirable to clean out the air compressor system at intervals, and wash out the carbon deposits before they grow to large proportions. Kerosene or any similar light oil must under no circumstances be used for this purpose, because of the danger of explosive mixtures due to their great volatility. Some operators look with favor on the use of soap suds for cleaning, the solution of soft soap and water being fed into the air intake or through the lubricator about ten times as fast as the usual oil supply. The quantity used must be judged by the amount of carbon found on the valves when they are inspected. After such an application all receivers must be blown down to remove all the soapy

water, and oil used again for a time before shutting down, in order to prevent rusting.

Fuel Pumps

The smoothness of operation of an engine is dependent on each spray valve being supplied with exactly the same quantity of fuel, and the sensitiveness of the control of the engine speed or power output is dependent on the ease with which the quantity of fuel delivered to the cylinders can be regulated. These pumps must accurately measure exceedingly small varying quantities of fuel and deliver them at just the right time, against an injection air pressure sometimes equal to 1000 lb. per sq. in. It is customary for a single pump with automatic valves to be used for each spray valve. With most engines control of the delivery is made by holding the inlet valve open during part of the delivery stroke. Figure 7 shows how this is accomplished, a being the pump plunger, and b the regulating-rod, both being driven

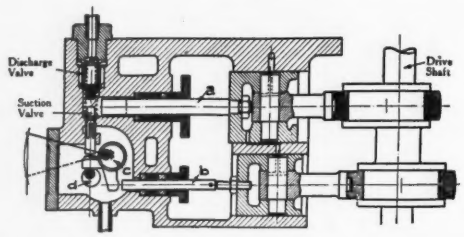


FIG. 7. SECTION OF A DIESEL FUEL PUMP WHICH REGULATES THE QUANTITY OF OIL DELIVERED ON EACH STROKE

by eccentrics. The eccentric driving the regulating-rod is so timed that it may or may not lift the suction valve, depending on the position of the bell-crank fulcrum c. Complete control of the delivery of fuel is maintained by varying this fulcrum. The engine may be stopped by rotating the eccentric d until the suction valve is held off its seat permanently, thus stopping the delivery of fuel. Further movement of eccentric d would raise the suction valve so far that it would also lift the discharge valve. This is done before starting an engine, when it is necessary to remove all air from the fuel lines. At each fuel injection valve there is a hand-operated overflow valve, which is opened when the discharge valve of the fuel pump is lifted as just mentioned. Then, if the fuel supply is above the fuel valve, fuel will flow by gravity through the fuel pump and lines up to the overflow valve. As soon as a steady flow of fuel is secured at this point the overflow valve should be closed. There is, of course, a check valve between the overflow valve and the fuel valve to prevent the escape of injection air when the overflow is opened. In some instances, especially marine installations, it is not possible to provide a gravity feed which will cause the flow just described, but the flow is caused by hand operated plungers on the fuel pump, or the pump itself is rotated.

Starting Diesel Engines

The conventional way to start a Diesel engine is to convert it momentarily into a compressed air motor by means of air valves in each cylinder, correctly timed for this purpose. Compressed air is supplied from air tanks, at 200 to 300 lb. per sq. in., and is turned on until the engine has made a few revolutions, when the air is shut off and the fuel turned on. Starting usually follows at once. Some engines start by cutting off the air from half the cylinders, so that half are "motoring" while the other half have fuel. Many stationary engines are equipped to supply starting air to only two or three cylinders, in which case it is necessary to turn the flywheel to the correct position before a start. Starting is sometimes facilitated by the use of a compression relief valve in each cylinder.

A cold engine can be started and put under full load in less than a minute's time, though it is, of course, desirable to give more time than this in order to allow the parts to warm gradually, or cracked cylinder heads may result.

Cooling of Pistons and Exhaust Valves

It has been found necessary to cool the pistons and exhaust of some large internal combustion engines, and it is probable that many engines of a medium size would perform better if they, too, were cooled by oil or water. One of the most frequently used methods of conveying the cooling liquid to and from a piston is by means of telescopic pipes. With some pipes packing is used while in other designs it is unnecessary.

Another system of piping consists of two hinged pipes, the outer end of one being hinged to the piston and the other to the frame. These oscillating joints are difficult to keep from wearing when using water for

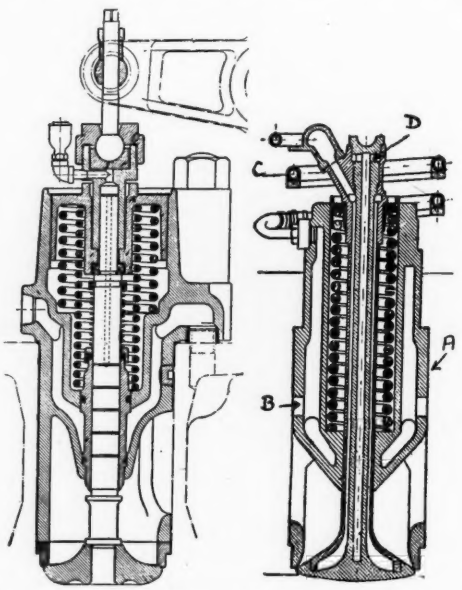


FIG. 8. LEFT: WATER-COOLED EXHAUST VALVE CAGE. RIGHT: WATER-COOLED EXHAUST VALVE AND CAGE

cooling. In all cases it is necessary to use an air chamber to dampen out the heavy pulsations resulting from the reciprocation of the piston.

Water is naturally the medium which would be used for piston cooling, but any leakage or splashing, especially if salt sea water is used, will in most designs have the serious result of getting the water mixed with the lubricating oil. With trunk piston types and for marine use since the water is salt the chance of trouble from leakage is avoided by using the lubricating oil itself as the cooling fluid. When the oil is pumped through

rapidly enough, there is no danger of its being injured because it rarely gets over 120 deg. F. Outside overflows into funnels, so that the oil may be felt by the hand, are very desirable in assuring from time to time that the system is working satisfactorily. The only disadvantage of using oil instead of water is that about twice as much oil must be used to secure the same cooling effect, and a larger oil cooler is required for the lubricating system.

As valves are invariably mounted in cages to facilitate removing them without disturbing the cylinder head, the exhaust valves are at best cooled only ineffectively by contact with the cylinder-head casting. In the designs shown in Fig. 8, the cages are separately water cooled, and the heat being carried away from the valve stems and guides results in a considerable cooling of the heads. In some cases even this is not enough and the valve is made hollow for a water circulation. Connections to the moving valve stem are then made by a flexible helical tube as shown, or by rubber tubing which, surprising as it may seem to the uninitiated, serves the purpose excellently.

Notes on British Power Plant Practice

THE CONTINUED HIGH PRICE OF FUEL IN THE BRITISH ISLES URGES ENGINEERS TO DIRECT ALL EFFORTS TOWARD SECURING HIGHER FUEL ECONOMY. BY C. H. S. TUPHOLME

SO SERIOUS has become the fuel question in Britain and thus, indirectly, the necessity for maintaining greater power plant efficiency, that various technical commercial organizations are urging upon their members the importance of adopting every means to increase the efficiency of their power units. The Federation of British Industries, an important and influential organization of employers, has established a fuel economy committee which is investigating the whole question of industrial power generation. This body has, as a start, issued the following recommendations.

1. Utilize the heat of the fuel as completely as possible in the boiler furnace, and deliver it to the heating surfaces in the form best suited for power transmission.

2. Secure the best possible transmission of this heat through the plates or tubes of the boiler for the generation of steam.

3. Avoid, as far as possible, losses of heat from the boiler plant.

4. Use steam as economically as possible for the requirements of the boiler plant itself in order to leave the maximum proportion available for external purposes.

5. Avoid unnecessary wastage of cinders in the ashes by cleaning the fires carefully and by providing suitable firebars.

6. Avoid the production of unnecessary smoke or incompletely burnt gases by the regular and frequent firing of coal in small quantities and by keeping a proper depth of fire. Open the air checks in the furnace doors only after firing, at other times keeping the checks closed.

7. Regulate the draft by the damper to burn the coal with the minimum excess of air. Try to obtain 12 per cent CO_2 in the furnace gases, and, if necessary, reduce the grate area to secure this result.

8. Keep the grate covered, the fires level and free from holes. Use the rake when necessary.

9. Carefully examine the setting and stop all inleakages of air.

10. Keep the heating surfaces free from soot and flue dust.

11. Keep the internal surfaces free from scale.

12. Do not force the boilers unnecessarily.

13. Examine flues and baffles carefully. Repair when necessary to avoid bypassing.

14. Efficiently lag the boilers and steam pipes, including flanges.

15. Do not blow down the boilers unnecessarily.

16. Keep the boilers filled to the working level by a continuous and steady feed.

17. Avoid leakages of steam from boiler fittings, drains, etc.

18. If steam is used in pumps or auxiliaries, use the exhaust for preheating the water.

19. If steam jet blowers are used, keep the jets in good condition by renewal as necessary, and regulate the pressure on the jets to the minimum necessary for the load.

20. If economizers are provided, record the temperatures of water entering and leaving.

21. Make periodical measurements of CO_2 in, and temperature of, flue gas leaving the boiler under average conditions to estimate the approximate boiler efficiency.

BRITISH POWER PLANT EXPERTS CONFER ON MEANS TO RAISE EFFICIENCY OF PLANTS THROUGHOUT BRITAIN

IN CONNECTION with the general campaign for fuel economy and power plant efficiency throughout Britain a conference has just been held at the Institution of Mechanical Engineers at which combustion and power experts were invited to express their views on the thermal efficiency of heat power plants and what means should be taken to induce greater economy and efficiency throughout Britain.

Modern boiler plant, says David Wilson, a combustion expert, can be designed to utilize on test 85 per cent of the available heat in the coal, and under daily operating conditions 75 per cent, and even 80 per cent in some cases, has been realized; yet the average efficiency throughout Britain does not exceed 50 per cent. Unfortunately the majority of plants are not modern and the present financial position suggests that it will take some time to bring all boiler plants up to date. Much, however, can be done by making the best use of the plant at present installed, and when that is done there will be sufficient saving to tempt industrial firms to replace obsolete plants by those of more efficient design.

The chief cause of inefficiency in British boiler houses is the lack of scientific supervision. It covers practically everything—even in works which are handi-

capped by having to use obsolete plant—given an engineer who thoroughly understands scientific control, he will soon convince his employers that it will be to their financial advantage to spend money on well-directed improvements. It is because coal consumption is not definitely equaled in the average industrial works, and because the manager is very skeptical of anyone who simply suggests that his coal bill might be reduced by 10 or 20 per cent that he is not prepared to pay the salary for a combustion engineer who would possess the expert knowledge necessary. As a rule, the salary offered is quite inadequate to tempt men who thoroughly understand the work. In one case where Mr. Wilson recommended a combustion engineer, he was paid £400 a year but the savings have been such that the firm now gives him £1000 a year, from which it will be seen that the salary is of little relative importance.

The first efforts should be concentrated on combustion—the dominating factor. It is no longer a difficult matter to maintain constant and accurate records of CO_2, final gas temperatures, carbon in ash, etc., and if these records are intelligently understood and acted upon by the engineer, economy will follow quickly. It is not a question of obtaining a few average readings; it is a question of ascertaining that every individual boiler is continuously working at its maximum efficiency, and that demands the services of at least one combustion expert who should devote his entire time to the work. In fact, an efficiently organized department under the Government could do much useful work.

In one large industrial town, Sheffield, they have jumped from about 20,000,000 units in three or four years to 172,000,000 units sold. That means a consumption of something like 5000 T. of coal per week for one industrial organization alone. The first thing the engineer did was to get two shift engineers in the boiler house; they found they had so much work to do that they could not look after combustion and attend to all the repairs, the firemen, and so on, so that the engineer could not get his efficiency above 65 per cent. He then got a chemist on the job who was a man of initiative. The chemist had two assistants and the consequence was that the general boilerhouse efficiency, including all banking of boilers and everything else, went up from 65 per cent to between 72 and 75 per cent. It is obvious, therefore, that if one concern can save 10 per cent on 5000 T. of coal a week, it can afford to pay a very fine salary to the man who effected the saving.

This engineer proposes to start a system of teamwork in the boiler house. If he can put gages in front of the boilers so that the men can see the draft, the steam consumption and the CO_2 in their boilers, and induce them to compete for the highest efficiency, they might be induced to educate themselves by attending the lectures which are provided for them.

Another engineer says he put combustion engineers on five Lancashire boilers two years ago and these men are now effecting considerable savings. In another case a combustion engineer was put in charge of eight Lancashire boilers; within three months of taking over he had shut down three of them and had given the works more steam than they had ever had before.

The Chemistry of Combustion

It is now generally accepted that the primary product of the oxidation of carbon is a complex of carbon and oxygen, which has a transitory existence, says E. V. Evans, F.I.C. This complex decomposes into a mixture of carbon monoxide and carbon dioxide in proportions which depend upon the temperatures at which decomposition takes place. The fundamental point of this hypothesis, which is confirmed by research, is that some carbon monoxide is formed directly without the intervention of carbon dioxide, and that a third reaction has to be added to the two so-called producer gas reactions. The combustion of hydrogen is a trimolecular reaction,

$$2H_2 + O_2 = 2H_2O$$

which is reversible at very high temperatures, and although intermediate stages in the oxidation process have been studied, the reaction is a simple one which calls for no special mention. The combustion of the simpler gaseous hydrocarbons introduces reactions which are more complex than either of these and, although combination with oxygen at high temperatures appears to take place in a simple manner, it has been shown that when combustion proceeds at low temperatures in the presence of a catalyst, many intermediate products are formed before the final product carbon dioxide and water vapor emerge. The apparent simplicity in the reactions involved in the combustion of simple gaseous hydrocarbons is, as a matter of fact, due to the high velocity of the reaction at these high temperatures.

In the combustion of raw coal the complexity of the reactions is augmented by a number of side reactions of a physical as well as of a chemical nature. The process is preceded and accompanied by the decomposition of the coal substance. Long before the ignition temperature of coal is reached some of the coal substance melts or decomposes into less complex bodies, and frequently with the evolution of gas, while the newly formed degradation products may also melt and further decompose. If the boiling point of any of these liquids is lower than the temperature of decomposition, distillation will take place immediately, and if the vapors come into contact with a cooler zone, condensation and smoke formation will result.

The gas may, however, become heated in the course of its passage, so that ignition takes place, but it is impossible to predict the sequence of events, as it is impossible to control the conditions to which the products of combustion will be subjected. There is no doubt but that the coal substance undergoes extensive decomposition, either in the solid or liquid form, prior to distillation. Whether the distillation products ignite or escape as smoke would appear to depend upon the relation between the ignition temperature and the boiling point. Where there is a large temperature difference, there is obviously greater opportunity for the gas to be carried away into a cooler zone before combustion occurs.

Another factor to be considered in connection with the combustion of smoke is the fact that it is usually evolved in a zone already highly charged with products of combustion from the fire below. For this reason a suitable excess of air must be provided, and if any such air is admitted to the combustion chamber above the level of the fire, it must be preheated to avoid cooling

the smoke below the ignition temperature. This does not apply to the use of such bodies as oil fuel or pulverized coal, the combustion of which may be controlled in the same way as that of gaseous fuel, though perhaps not to the same extent. The use of raw coal is to be deprecated, owing to the impossibility of controlling the combustion process, of which the complexity has been shown, and because the combustion of raw coal represents to the chemist an appalling waste of inorganic and organic chemical products, upon which depends mainly the building up of an organic chemical industry.

Waste-Heat Utilization

The most desirable result from a fuel economy point of view, says Robert Nelson, is obtained by organizing a works so as to make it self-contained as regards heat production and heat utilization, aiming at the elimination of surplus heat altogether. Though the abolition of surplus heat may sound like a counsel of perfection, the trend of recent development in heat utilization is in that direction.

Blast furnace owners and steel makers in Britain are now of opinion that in the interests of fuel, transport and labor, the two businesses of pig-iron manufacture and steel making should be organized as one, and the plant so disposed as to admit of coal and iron ore being brought in at one end of the works and finished steel sent out at the other; for the surplus heat in the coke oven and blast furnace gases is known to be sufficient, first to convert the molten iron into steel ingots, and secondly to roll the ingots into finished steel sections.

But, speaking generally, the actual supply of surplus heat is rarely if ever found to synchronize exactly with the demand for power. Apart from hourly and day-to-day variations, there are week-ends when, while the supply of power in the form of surplus heat remains nearly constant, the demand for power in the works falls practically to zero. Here the power distribution mains of an efficient electricity supply may be utilized with great advantage.

In many cases the only practicable means of utilizing surplus heat is by co-operation between the waste-heat owner and an electric power supply undertaking. In this connection it should be remembered by waste-heat owners that the high efficiency of modern coal-fired generating plant places a strict limit on the economical value of surplus heat for generating electricity. The margin between the cost of coal-generated electricity and the cost of surplus-heat generated electricity being very small, the surplus-heat owner should not expect to receive a price for his surplus heat which is economically impossible.

Superheating

Says Sir Henry Fowler: The development of superheating many years ago was arrested by the difficulty of lubrication which has been solved by the progress made in mineral oils. Pure mineral oils have not been found satisfactory, and the best results have been obtained with blended oils, composed mainly of mineral oil with small quantities of fatty oil. One trouble which has not yet been perfectly overcome on locomotives is the deposits which accumulate in the cylinders and ports, and which have to be removed periodically.

The amount of superheat which can be given to the steam has gradually increased, owing to lubrication improvements. Ten years ago, 150 deg. F. was quite a usual amount to give to steam used in turbines, but in locomotives it frequently rose to over 300 deg. F. for short periods. Now, although the latter figure is rarely exceeded for any length of time in locomotives, it is worked up to in turbine practice. Roughly, within certain limits, the practical saving in steam with turbines is a little above 1 per cent for every 10 deg. F. of superheat. With locomotives the saving varies between 15 per cent and 25 per cent, depending largely on circumstances.

In order to do away to a large extent with the fluctuation of firing up, etc., it is often advisable to cover the tubes of the superheater of stationary boilers with some substance which will help to store the heat, so that the degree of superheat may be fairly constant. The chief change in locomotive practice is the abandonment of every type of damper without any detrimental effect. The cast-iron header has been in use for 10 yr. with perfectly satisfactory results.

Feed Heating and Economizers

According to C. E. Stromeyer, for economizers the range of temperature is limited at the upper end by the temperature of the boiler water, and at the lower end by that of the feed which must be at least 100 to 120 deg. F. on account of flue gas moisture and corrosion. Colder feed supplies have to be warmed by feed heaters. Economizers suffer comparatively little economic depreciation due to the accumulation of scale or soot, but economizers and feed-heaters have their efficiency reduced by the increasing thickness of coatings. The external deposits are scraped off continuously; the internal deposits are, only too often, allowed to accumulate. Evaporators are of the nature of feed-heaters, but fulfill the further duty of supplying pure make-up feed. Usually the evaporate is condensed in the main condenser, but recently vapor-compression evaporators have met with some success, the vapor which is generated on one side of the heating surface being compressed and delivered against the other side.

The chief economizer troubles are external corrosion due to the condensation of moisture in the waste gases, and internal corrosion due to air in the supply water. Incrustation is also a serious trouble, especially in limestone and chalk districts. The internal troubles are aggravated by the slowness of the movement of the water. Economizer pipe failures are of frequent occurrence, but are of no serious consequence. Occasionally economizers explode. These serious accidents are apparently due to generation accidentally of steam in the pipes, resulting in irregular ebullition and bumping.

The Indicator as an Aid to Economy

The indicator diagram gives valuable information about the timing of the cycle of operations and about valve-setting, says Professor W. E. Dalby, and this is as important as the determination of horsepower. In quick running internal-combustion engine a mere fraction of a second difference in timing makes a large difference in the power developed and the quickest and best way of obtaining the proper setting of an engine is by means of an indicator. For indicating engines in which pressure changes are rapid, the moving parts of the instru-

ment must be reduced to the smallest possible mass in order to avoid inertia errors and even then the movements must be small.

With such limitations, diagrams of convenient size can be most easily obtained optically. Optical indicators may be divided into two types:

(1) The piston type.

(2) The disk or diaphragm type.

The piston type was developed by the late Professor Hopkinson and subsequently by Professor Burstall. The disk type is represented in the Carpentier instrument and in the indicator designed by Professor Dalby, also in the late Professor Watson's instrument.

The Carpentier indicator has one mirror receiving two motions at right angles to each other, one proportional to pressure and the other to the stroke, whereas in the Dalby-Watson indicator two mirrors are provided, one for each motion. When used with quick-running engines, the spot of light, reflected on to a ground glass screen, travels so quickly that the eye sees a complete indicator diagram traced out in light, and the slightest variation in the conditions in the cylinder is instantaneously seen in the change of shape of the diagram. The objection to the diaphragm indicator is that the diaphragm gets hot and slightly changes its scale, but this disadvantage is outweighed by the many advantages which such an indicator possesses.

Purification and Degassing of Boiler Feed Water

According to Paul Kestner, who read a paper on boiler feed waters to the Institution of Mechanical Engineers, hot purification of feed water effects a thermal saving, and has the further advantage of eliminating the gases dissolved in the feed water by the reduction in solubility at a high temperature. The speed at which the reaction takes place in the purification of water by soda alone or lime and soda can be accelerated by heat and the settlement of the precipitate can be hastened by agitation, the effect of which is to cause accretion and increase in size of the particles. If the agitation is caused by a stream of water carrying air with it, the water becomes saturated with oxygen and corrosion results.

In water-softening processes generally rise of temperature insures:

(a) Increased speed of reaction.

(b) Reduced viscosity of the water.

(c) Reduction of the bicarbonates of the alkaline earths to carbonates.

(d) Reduced solubility of calcium sulphate and partial precipitation without the use of reagents.

Whatever method of purification is employed, all the salts carried into the boiler by the feed water becomes concentrated in it. In general, some calcium carbonate remains in solution in the water and when the concentration produced by evaporation becomes sufficiently high it is deposited on the walls of the boiler or in the tubes, forming incrustation, which is harder the more slowly the deposit is made. In boilers generating steam very rapidly the deposits are also formed rapidly and may accumulate in the tubes, notwithstanding the rapidity of the circulation. The usual remedy is periodic blowing off from the lowest point in the boiler and, to be effective, a large actual quantity of water must be blown off at each operation, even though such should not form a large proportion of the boiler contents.

Continuous blowdown allows the calories to be saved by passing the blowdown water through a feed water heater, the mud being deposited in a trap during the process, together with the salts that had been retained in solution owing to the high temperature of the liquid. The only loss occurs in the actual removal of the mud and salts which forms a relatively small quantity. The blowdown water freed from the impurities is then returned to the boiler. This prevents the concentration of the double salts to an extent at which they would constitute a danger.

The process of continuous blowing down permits the contents of the boiler to be renewed frequently; it eliminates mud before it has time to accumulate, and at the same time allows the use of soda for the reduction of the calcareous bicarbonates. The feed water therefore contains sodium carbonate and bicarbonate; the latter is decomposed in the boiler into carbonate, and the carbonate in its turn is dissociated in the presence of water with a reversible condition of equilibrium in functions of the initial concentration and the temperature, thus:

$$CO_3Na_2 + H_2O = 2NaOH + CO_2$$

hydrolysis giving more caustic soda the higher the temperature.

With continuous blowing-down the water containing caustic soda and carbonate of soda is used to purify the make-up feed, the caustic soda reacting more rapidly on the calcium bicarbonate than would calcium oxide. It is of great importance, therefore, to combine purification by soda with the continuous blowing-down process.

The Kestner continuous blowdown apparatus consists of a steam separator, a central reservoir receiving the blowdown liquid, an annular chamber surrounding this reservoir, from which it derives heat and into which the purified blowdown water is decanted. The steam passes into a reheater in which it heats the feed. The heated feed mixes with the blowdown as it leaves the central chamber and then passes to the annular chamber in which precipitation and settlement take place. Soda is added through a water meter in proportion to the make-up feed. Valves are provided for separating the mud.

The distilled water of industrial appliances differs greatly from that of the laboratory. Owing to the rate of evaporation, particles of water containing salts are carried over, so that the distilled water contains numerous soluble salts in small but by no means negligible quantity, and in the boilers using distilled water it becomes in time a fairly concentrated liquid. Boilers working with distilled water, therefore, require to be blown down occasionally, but it is not necessary to remove a large amount of liquid, the amount usually being 1 to 2 per cent, the saline solution being replaced by distilled water. Even when an evaporator is used, the continuous blowing-down method can be adopted, and in conjunction with degassing enable a complete closed water circuit to be arranged in a central station using distilled water.

Where distilled water is used there can be no doubt as to the cause of corrosion. Oxidation of the plates

can only be produced by oxygen dissolved in the feed water and set free in the boiler, and the effect is greater with intermittent working.

The air dissolved in water contains about 33 per cent of oxygen and the elimination of this dissolved oxygen may be effected by physical or by chemical methods, or both.

Paul Kestner's investigations have led to the design of an apparatus due to the discovery that when an iron degasser that had become completely rusted was left at rest it was found after a day to have undergone a change and from red rust to have become greenish-black, due to the reduction of ferric hydrate under the influence of the iron. This has led to the invention of the Paris degasser, which works on the regeneration principle. In one form by means of two vessels containing iron turnings, through which flow takes place alternately; and in the other form in a single vessel with filters at each end and a valve arrangement for permitting the direction of flow to be altered. The amount of iron used in the apparatus is stated to vary from 1 to 3 grammes per ton of water treated, and the amount so used corresponds to the weight of boiler-plate saved from destruction.

Ashes Handling

USING THE SAME APPARATUS FOR COAL AND ASHES CONVEYING. BY STAUNTON B. PECK

THERE is an impression, more or less prevalent, that while pivoted bucket carriers are highly satisfactory for handling coal in power houses, they are not satisfactory for ashes, and that some other device should be provided for the latter purpose.

The carrier is generally recognized as a fine and relatively costly machine, and one of the most efficient devices for handling coal. Ashes are known to be destructive of machinery through abrasion and corrosion, and for this reason it is generally concluded that they should be handled in a separate machine provided for them.

What is usually lost sight of here is that the use of a separate machine does not eliminate the destructive wear and corrosion, but is merely a transfer of it to another machine. It is undoubtedly true that the handling of ashes by a carrier increases the annual maintenance cost; but the records of a very large number of carriers handling both coal and ashes, indicate conclusively that under average conditions the increased maintenance costs due to the ashes, nowhere nearly equal the cost of upkeep, interest and depreciation on a separate ashes handling device.

The largest watch manufacturing company in the world gives in 1914 accurately detailed costs of the maintenance of its carrier since its installation in 1905, totalling $92.40.

A ship-building company on the Great Lakes wrote to the manufacturer in 1908 about a carrier installed in 1903, as follows: "We are pleased to inform you that it is giving very satisfactory service, and is at this time in first-class running repair. This carrier has caused us little or no trouble, and the few minor repairs which we have made are the result of accident, rather than any fault of the machinery."

One of the leading railroads in the country wrote in 1910 about a carrier installed in 1903: "The service received from this arrangement has been very satisfactory; the repairs made have been very slight, and have not amounted to approximately over $25 a year since the installation."

The largest car manufacturing concern in the country writes: "With reference to the pivoted bucket carrier installed some 5 yr. ago, you are advised that this machine is in good condition, and an approximate figure of $100 would cover the expense of wear and tear."

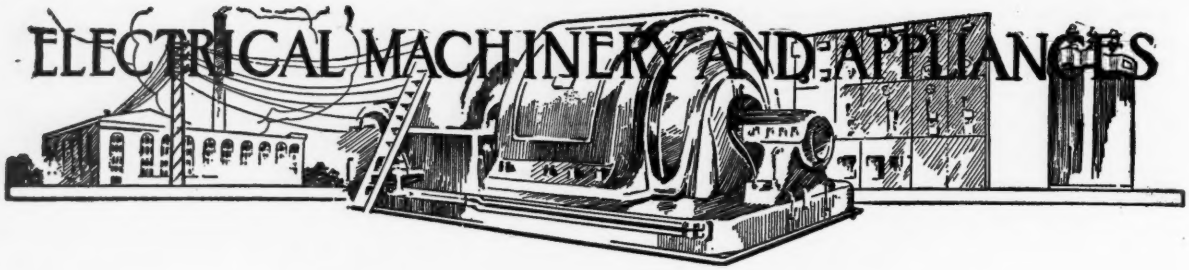
All of the above carriers handle both coal and ashes, operate under average working conditions, and undoubtedly receive reasonable care and attention. The foregoing figures show conclusively that there is no justification for a separate ashes handling machine.

The records of several hundred carriers which have been carefully kept do not contain a single specific complaint on the ashes score, and there have been extremely few where the maintenance charges have been unreasonably high. In every case where the repairs have been abnormal it has been due to some unusual condition, or neglect, and not in any way traceable to the handling of ashes.

The use of an independent machine for handling ashes may be justified in a very large power house where the quantities of coal and ashes handled are so great as to make two machines of moderate size more desirable than a single, very large machine. But in the great majority of cases a single carrier running in front of the ash pits, and encircling the overhead coal bin in front of the boilers, is an arrangement that is hard to beat, and has a convincing record of satisfactory performance back of it.

TESTS HAVE been made at the Pittsburgh Experiment Station of the Bureau of Mines on the Speller process for removing dissolved oxygen in hot-water heating systems. This process endeavors, by removing dissolved oxygen from the water, to retard corrosion of the hot-water pipes. An installation has been in use at the Pittsburgh station for about a year. The first test showed that the water heater did not heat the water to a high temperature when the most water is being used in the building, so the heater was covered with asbestos and a second test made. The oxygen deactivator proved efficient in removing dissolved oxygen provided the water entering the deactivator was kept at about 170 deg. F. The investigation is being continued.

ACCORDING TO the report issued by the Department of Commerce, tabulations show that there is $450,000,000 now available in the United States for local improvements. Eighty per cent of the communities affected have notified the Conference on Unemployment that work is already in progress, or that it will be started before spring in order to provide local employment. Many public works officials have notified the Conference that they are awarding contracts only on condition that the work be prosecuted throughout the winter whenever weather conditions permit. The Conference is keeping in close touch with contemplated public projects in order to get the maximum relief from unemployment.



Direct Current Circuit Breakers

A Discussion of the Operating Characteristics of D. C. Circuit Breakers and Their Fields of Application. By John C. Kahl

THE PROTECTIVE features commonly associated with motor circuit breakers may be enumerated as follows: Overload, no voltage, shunt trip and time limit. The overload circuit breaker protects the motor from being unduly loaded through any cause whatsoever. Overloads may be caused in numerous ways, such as too rapid starting of the motor, by working the motor driven machine beyond its capacity, by faulty adjustment of the driven machine, etc. With respect to the first cause, therefore, due attention should be given when selecting an overload circuit breaker to the amount of current required at starting. With starting rheostats of the usual type the starting currents of motors of the sizes in ordinary commercial use run approximately 50 per cent in excess of full load current.

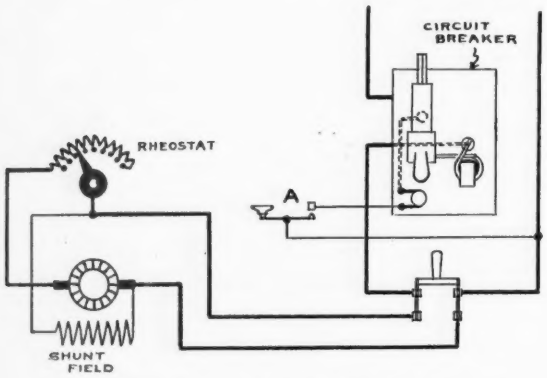


FIG. 1. DIAGRAM OF CONNECTIONS FOR A SINGLE POLE OVERLOAD AND SHUNT TRIP CIRCUIT BREAKER FOR PROTECTION OF MOTOR

Circuit breakers should therefore be chosen which have a sufficiently high adjustment to meet this requirement satisfactorily. Usually it is not desirable to have the circuit breaker operate in the event of briefly sustained overloads of inconsiderable magnitude, but to limit its action to that occasioned by sustained overloads or those of excessive magnitude. For instance, with motors driving such machines as stone crushers, punching machinery, shears, etc., sudden overloads of brief duration are met with. For such service the overload feature should have an inverse time lag; that is, it should be sensitive to small overloads only when continued unduly long, but should respond more quickly to the heavier loads, the time lag becoming less as the overload increases and altogether disappearing in the case of excessive overload.

No Voltage Release

WHERE THE source of the current supply is liable to occasional interruption, the no voltage feature is an essential adjunct to the circuit breaker for motor protection. The direct current motor is so constructed that it should only be brought into circuit gradually as by means of a suitable starting resistance. If at any time after reaching full speed the power supply is interrupted long enough to permit the motor to slow down or to stop altogether and is then restored with the motor starter in the running position, the motor receives current much in excess of its capacity, a condition which is likely to result in injury not only to the motor but also to the machine driven by it. The no voltage circuit breaker will prevent this by automatically disconnecting the power supply if the voltage falls considerably below normal.

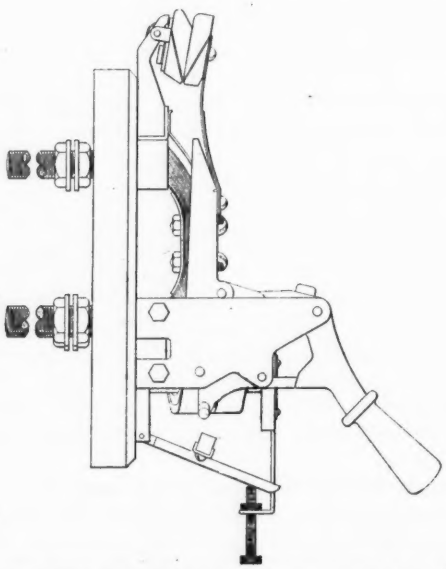


FIG. 2. SIDE VIEW OF INVERSE TIME LIMIT OVERLOAD CIRCUIT BREAKER

For manually controlled variable speed motors, the no voltage circuit breaker is especially valuable, as it is not unusual to embody the protective features afforded

by this type of apparatus in the controllers. The no voltage circuit breaker protects more effectively than any other piece of apparatus against the conditions incident upon interruption of service because, being especially designed for opening circuits with final breaking points of solid carbon, the main contacts are not liable to burning.

Shunt Trip Feature

Where conditions are likely to arise in the operation of electric motors rendering it desirable to open the circuit at will independent of the load, the shunt trip feature should be employed in conjunction with the circuit breaker. It consists of a tripping magnet having a high resistance coil normally out of circuit adapted to be brought into circuit either automatically upon the occurrence of any predetermined mechanical condition or by hand as necessity requires. This feature is especially desirable or useful in connection with crane motors where by the use of suitable devices for automatically closing the circuit of the shunt trip coil, over travel of the motor operated hoists may be prevented. The movement of motor driven draw bridges may be conveniently limited in the same manner. Motor operated pumps may by this means be automatically cut out by using a float operated switch to bring the shunt trip feature into operation when the liquid in the tank supplied by the pump reaches the desired height and by similar means, the motors operating air compressors may be automatically cut out when the desired pressure is attained.

Where material handled by a motor operated machine is of a readily destructible nature it is often highly desirable that the operator shall be able to cut the power off instantly from any point about the machine under his care. This is easily accomplished by the use of a circuit breaker having a shunt trip feature with its coil connected in circuit through a number of normally open switches arranged in parallel and being so located that one or more of them is at all times within reach of the operator. Textile factories employing individual drive offer a class of service in which circuit breakers with shunt trip features are found advantageous and it might be said are absolutely necessary. Protecting each motor by a circuit breaker greatly lessens liability of injury to employes because of the means thus provided to cut off the power instantly from any machine. With motor driven printing presses circuit breakers with the shunt trip feature are indispensable. Here the destructive nature of the substance handled makes it essential that the operator be able to cut off the power instantly from any point around the press. In work of a particularly exacting nature the press is sometimes equipped with switches in circuit with the shunt coil which are automatically closed by any irregularity in the run of the paper.

In the event of two or more motor driven machines handling the same material, it is often of greatest importance that where one machine of the motor driven group becomes inoperative the others must also be stopped. Such conditions are frequently met in the case of motors operating traveling cranes, and coal and ore handling machinery, also in certain classes of manufacturing where the supply of material for each motor driven machine depends upon the continued operation of the other machines of the group handling the same material. A multi-coil overload and shunt trip circuit breaker is especially designed for this class of service. In addition to the shunt trip, it is provided with one overload coil for each motor of the group and a single switch member, the latter to be connected between the motors and the common source of supply. This arrangement produces such results that an overload on any one of the motors operated through this circuit breaker will cause the disconnection of them all. Additionally the shunt trip feature affords a convenient means of opening the circuit breaker through hand operated push button or by automatically actuated limit or stop devices. The same results may be secured by the use of a separate circuit breaker for each motor, the breakers being so interconnected that the opening of the one results in the opening of them all.

Single vs. Double Pole Circuit Breakers

The question often arises in choosing a circuit breaker for direct current protection, shall a single-pole or a double-pole breaker be used? It sometimes happens that where a motor is connected to a two-wire system it is protected by a single pole circuit breaker. Where this happens the underwriters require that a hand switch be connected in series with it. When with this arrangement the circuit breaker opens the hand

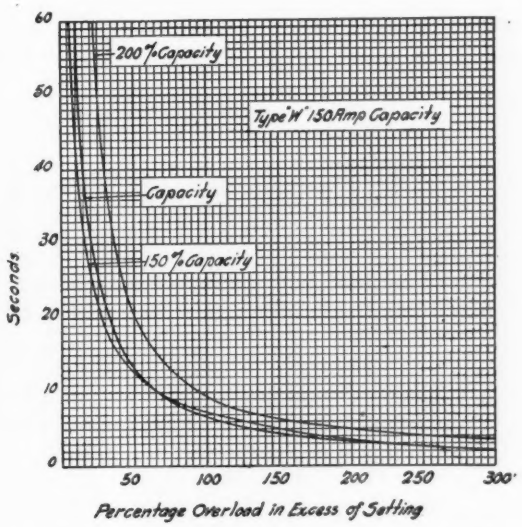


Fig. 3. Operating characteristics of a 150-amp. d. c. circuit breaker

switch should be opened before the circuit breaker is closed. Then when the circuit is completed by the closing of the hand switch the circuit is free to respond should abnormal load conditions exist on the line where through haste or ignorance the operator fails to observe this method of operation and the circuit breaker is closed without first opening the hand switch should the overhead conditions still exist. Damage to the apparatus or to the operator is almost certain to result. Accidents from this source are rendered impossible by the employment of double arm circuit breakers. This type of instrument in its most usual form is an instrument of the double-pole type, the two switch members of which while capable of being closed independently are

controlled by the same tripping mechanism. It combines the function of both switches and circuit breaker in a single instrument. With each side of the line protected by a circuit breaker the usual hand switch is rendered superfluous and the possibility of damage from overload completely eliminated. This condition is also secured by the use of a circuit breaker which cannot be closed or held closed during the continuance of overload on the circuit which it protects. Should an overload arise during the act of closing the circuit breaker the switch arm will instantly be released from the closing lever and the circuit will be broken regardless of any pressure which may be exerted upon the handle.

In three-wire direct current installations the neutral main is usually grounded for the protection of a motor operated from such a system. A double-pole double-coil circuit breaker becomes necessary, thereby insuring immediate response in the event of accidental grounding of either the positive or negative mains.

Generator Protection

The choice of circuit breakers for the protection of generators depends upon the nature of the installation, the number and class of generators employed, the character of service required and the degree to which it may be desired to eliminate the human element from the operation of the generating plant. The most elementary case is presented by an installation consisting of a single two-wire generator. Here it might be suggested that the best breaker would be one of the double-pole type.

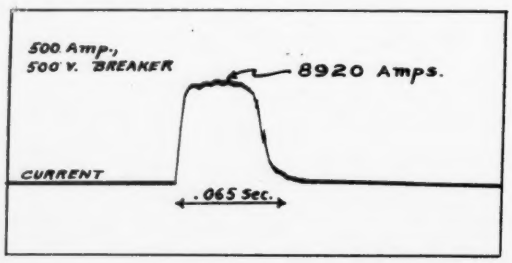


Fig. 4. Oscillograph showing action of a 500-amp., 500-v. circuit breaker in opening the circuit at 8920 amp.

Assuming that one lead of this generator is grounded and that the circuit breaker is of the single overload coil type, then the pole of the breaker of which the overload coil forms a part should be connected into the ungrounded lead. Assuming, however, that a single-pole circuit breaker of standard construction has been provided, then to satisfy underwriters' requirements it becomes absolutely necessary just as in the case of motor protection to place a hand switch in series with the circuit breaker and it is highly essential that this switch be opened before closing the circuit breaker for the simple reason that should the external circuit be in condition to produce excessive current flow, upon the attempted closure of the breaker the responsive action of the latter being interfered with by the operator's hand would thus be ineffective, the generator would probably be damaged by the resulting overload and the operator injured by too close proximity to the arc caused upon the retarded opening of the circuit breaker. The experience is a trying one not only to the generator, but also to the circuit breaker, the effectiveness of which is in a large measure dependent upon its quickness of action. This contingency should be guarded against by the use of a circuit breaker of the double arm form, which was described under motor protection. Where generators operate in parallel it is important that each carry its proper proportion of the load. Conditions may, however, arise which will disturb this balance and cause the generator thus affected to act reversely, that is, to draw current from the system instead of contributing current to it. Such a condition may arise as the result of complete or partial failure of the motive power associated with the unit, or through loss of field excitation as might be caused by a break in the shunt field circuit from a breakdown of insulation of the armature windings. The generator thus affected not only fails to carry any portion of the external load but by taking current from the system adds to the load to be carried by the other generators. It should therefore be promptly disconnected from the system.

Reverse Current Circuit Breakers

To meet this condition in a satisfactory manner a reverse current circuit breaker is employed which, acting immediately to a reversal in the direction of the current automatically disconnects the disabled generator before it becomes a tax upon those carrying the external load and also before the motoring action can take place. In generating plants the demands upon which are of such a nature that reserve units must be frequently thrown into service, reverse current circuit breakers built on the double-arm principle are of especial value. Where each generator is protected by this type of circuit breaker, no unit can effectively be thrown into parallel with the others until the proper voltage relation is established and the operating engineer may go about his work being confident that the generators will be protected from all contingencies. For generators operating in parallel with equalizer connections, the only practical circuit breaker that can be recommended is the three-pole circuit breaker in which the two poles of the circuit breaker by means of which the equalizer and the corresponding main lead are connected into circuit may be rigidly united. Independent breakers may be used, but should be so interlocked with an independent pole connected into the other main lead that the two first mentioned poles must be closed before it will be possible to close the latter and the opening or tripping of this latter pole must cause the opening also of the two first mentioned. This arrangement insures making the connections in their proper sequence and gives protection to the generator not only during running conditions, but likewise during the critical period when the last pole of the circuit breaker is being closed and is under restraint of the operator's hands. While hardly so complete or symmetrical an arrangement as the foregoing, the use of a double-pole double-arm circuit breaker in the main leads of the generator supplemented by a hand switch in the equalizer lead gives effective protection. The advantage of the double-arm feature has already been referred to. When a double-pole circuit breaker is used, it must be remembered that its operation still leaves the disconnected generator alive until the hand switch in the equalizer lead is opened. In connecting circuit breakers into the leads of

compound wound generators, care must be exercised that the pole containing the operating coil be connected in the generator lead which is not immediately connected with the series field winding. The operating coil thus carries the full current of the armature, whereas if placed in the opposite side, it would carry more or less depending upon the current carried by the equalizer connection.

It frequently happens that the generating equipment is subject to more or less heavy overloads which are too brief in their duration to be damaging and where this is the case the generating units should be protected by direct acting time limit circuit breakers.

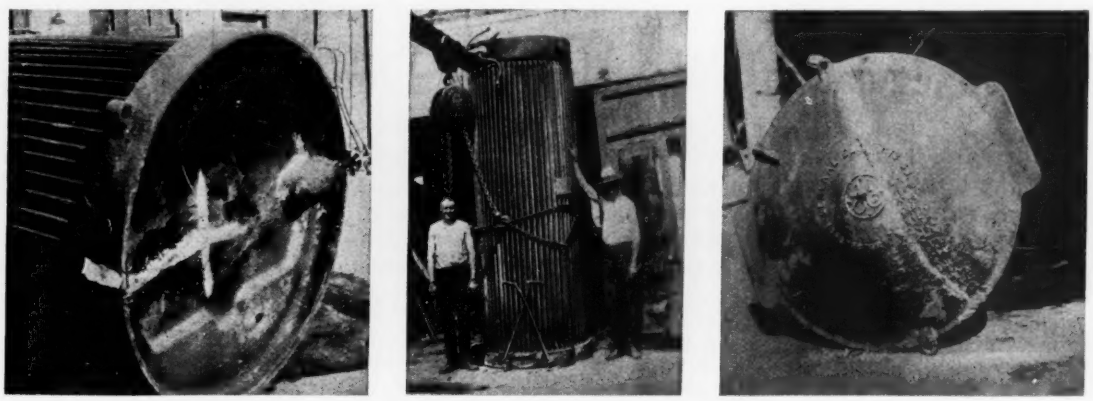
Transformer Case Repaired by Welding

AN INTERESTING case of transformer case repair was recently accomplished by the Dubler-Welding Co., of Tulsa, Oklahoma. While not so heavy a job as some that are handled in the oil field district, it is unusual enough to merit description.

Both the base and the top of a General Electric transformer case, in service at the Tulsa plant of the Public Service Co. of Oklahoma, were very badly cracked, rendering the equipment useless until the parts were either repaired or replaced. It was decided that economy, both in time and cost, would be effected by employing oxy-acetylene welding in event that such a repair were practicable. The case, being 14 ft. high and 4 ft. in diameter and weighing approximately 1400 lb., unwieldy at best, was rendered especially so from iron, was cracked almost straight across the center from edge to edge.

No unusual difficulties were encountered in welding the top, owing to the fact that it was easily removed and could be handled in the ordinary way. It was quite different, however, with the base, which, as stated, was securely bonded to the steel shell of the case. Owing to the length of the drum, the case had to be laid on its side throughout the entire operation, thus rendering the work more difficult of access and of execution.

In preparing the base for welding, the edges of the breaks were beveled to an angle of 45 deg. with a cutting blowpipe instead of with the cold chisel or air-chisel, as was formerly necessary in all chamfering operations on cast iron. The preheating was done by directing large gas flames on the entire lower end of the case and gradually elevating the temperature through a period of 7 hr. The actual welding occupied about 4 hr., during which time fully 30 lb. of filler rods were deposited. The base was then allowed to cool very slowly, after which the weld was subjected to the usual water test for leaks. It was found to be perfectly sound, not even a pinhole having to be closed.



VIEWS ILLUSTRATING TRANSFORMER CASE REPAIR

a welding point of view because of the location and character of the break in the base, on which it was necessary to do vertical welding. Moreover, the drum, or body of the case, was of steel, while the base, to which it was thoroughly bonded, was of cast iron, thereby complicating the problem of expansion and contraction.

The fracture in the base, a casting 7/8 in. in thickness, started at a point near the center, extending to and through a 4-in. flange at the periphery. There was also a transverse crack near the center, producing the effect of a cross. The opening at the flange was fully 2 in. wide, indicating that the casting had been subject to intense internal strain probably from the time it left the moulding flask in the foundry. The top, also cast

Storing Storage Batteries

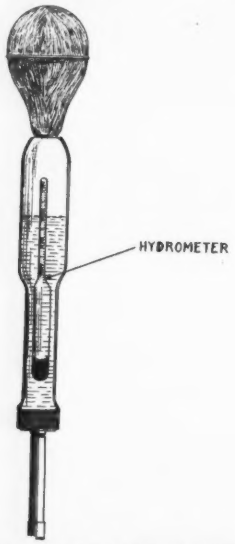
By Victor H. Todd

WHEN A storage battery is going out of service for a considerable length of time, as for instance when an automobile is put up for the winter, there are a number of precautions which must be taken in order that the battery will be in fair condition in the spring and will not deteriorate from standing so long. Batteries may be stored either "wet," that is with electrolyte in them, or "dry," in which case the electrolyte is removed.

In either case, the first point to watch is that each cell is fully charged. This may be determined by the syringe hydrometer or a voltmeter. A syringe hydrometer is shown herewith. Some electrolyte is sucked up into the tube and the inclosed hydrometer, floating in the liquid, will indicate the specific gravity. A fully charged battery will indicate 1.285 at 70 deg. F. and a practically discharged battery will show 1.225. If the temperature is warmer than 70 deg. F., it is necessary to supply a correction as follows: Add 0.0003 to the

hydrometer reading for every degree F. warmer than 70 deg. F. and subtract 0.0003 for every degree lower than 70 deg. F. Thus the corrected reading of electrolyte showing 1.276 at 100 deg. would be 1.276 (30×0.0003), or 1.285.

Unless voltage readings are properly taken, they are liable to be very misleading, as a storage battery may



SYRINGE HYDROMETER USED IN TESTING STORAGE BATTERIES

show 2 v. per cell on open circuit even when practically discharged. The correct way is to put a load of several amperes on first. For instance, in an automobile, stop the engine and turn all the lights on. A fully charged battery (not charging, however) will indicate slightly over 2 v. per cell while a discharged battery will show only 1.85 v.

In case of doubt, the battery should be given an overcharge, charging until no rise in voltage or specific gravity is noted for an hour, and the cells are all gassing freely.

If the cell is to be left in this condition, i. e., stored "wet," it should be placed in a dry place where the temperature never goes below 40 deg. F. This is especially true if water has been added after charging, as the water is lighter than the electrolyte and will float to the top where it may freeze and damage the battery. A battery left in this condition gradually loses its charge and should be charged at monthly intervals to keep it in good condition. If impossible to keep in a warm place, the battery must never be allowed to become discharged, even when in service, as a discharged battery will freeze at 10 deg. F.

When a battery is to be stored dry, it should first be given a thorough overcharge, using the 24-hr. rate specified for the battery. Then invert the battery and drain the acid into a glass, rubber or glazed earthenware dish. Drain for at least 5 min. and save the electrolyte for future use. Fill the battery with distilled or tested water immediately, allowing it to remain in at least a minute; then drain and refill, continuing this washing process at least five times, and allowing the last washing to drain out for 5 min. Screw in the vent plugs, which have been previously dipped in melted paraffine, at once and close the battery air-tight if possible, using paraffine to stop up any vent holes or other openings.

In this manner a battery may be stored throughout the winter and is easily put in service in the springtime.

Speed Regulation and Stability of Direct Current Motors

ANALYZING THE ELEMENTS AFFECTING THE CHANGE OF SPEED UPON LOADING DIRECT CURRENT MOTORS. BY SCOTT HANCOCK

CONSTANT-SPEED, direct-current motors are usually called shunt wound motors. The use of the term "shunt wound" may be misleading to a slight extent, as many of the constant speed motors, even though called shunt wound, have a small series field. The term "constant speed" is also to a certain extent misleading. The term would indicate that the

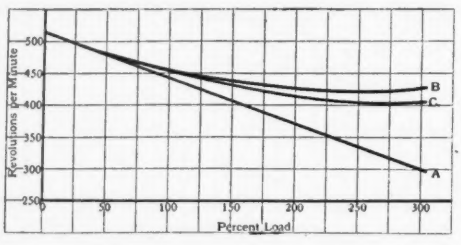


FIG. 1. FULL FIELD SPEED REGULATION CURVES AS AFFECTED BY VARIOUS FACTORS

motor speed does not vary with the load. Actually the speed stays only approximately constant. It not only does not stay constant, but it does not even follow a straight line; that is, the speed at half load would not be exactly midway between that at full load and that at no load. An analysis of the elements affecting the change of speed upon loading will show: (a) why the slight series is used; (b) what should be expected in the speed regulation curve; and (c) how the shape of this curve can be changed.

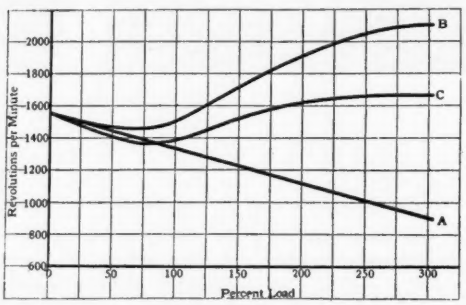


FIG. 2. WEAK FIELD SPEED REGULATION CURVES AS AFFECTED BY VARIOUS FACTORS

Only two things affect the induced voltage in the armature of a motor. First is the line voltage, which is assumed to be constant, and second is the IR drop in the brushes, armature, commutating coil, series coil

and any other resistance that may be in series with the armature.

In a given machine the flux is affected principally by the following five things:

1. The shunt field excitation. This is assumed not to be affected by load.
2. The armature distortion.
3. The series fields.
4. The position of the brushes.
5. The commutating field strength.

To make the effect of these factors more clear, a tentative design is given for a 10-hp., 500/1500-r.p.m. motor and calculations so far as practicable showing the

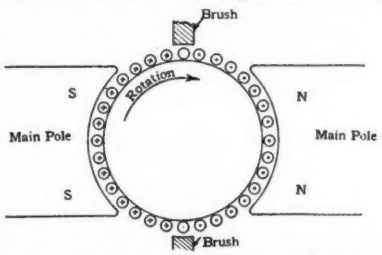


FIG. 3. DIAGRAM SHOWING CAUSE OF CROSS MAGNETIZING EFFECT OF A LOADED ARMATURE

effect of each of the above factors on the speed regulation curve.

First consider the flux as constant at all loads and consider the effect of the increase of *IR* drop on the speed. *E*, the voltage to be induced, is equal to the line voltage minus the *IR* drop. Neglecting brush drop, which is small, the *IR* drop is directly proportional to the armature amperes (or load). In all cases where there is considerable *IR* drop it will be practically pro-

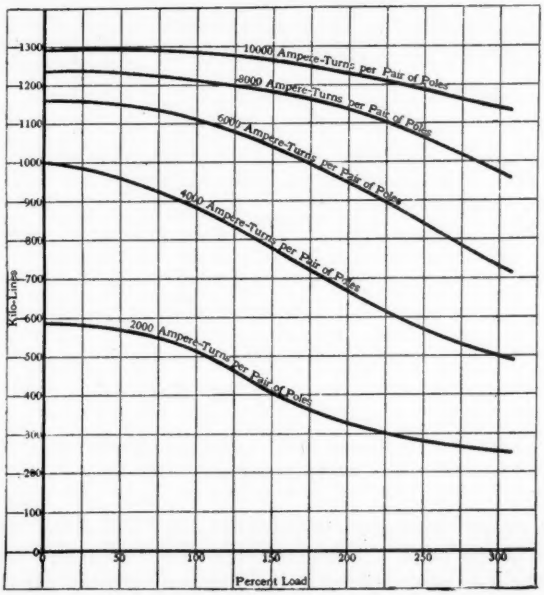

10000 Ampere-Turns per Pair of Poles
8000 Ampere-Turns per Pair of Poles
6000 Ampere-Turns per Pair of Poles
4000 Ampere-Turns per Pair of Poles
2000 Ampere-Turns per Pair of Poles
Kilo-Lines
Percent Load

FIG. 4. CALCULATED SATURATION CURVES OF THE 10-HP. 500/1500-R.P.M. MOTOR AT VARIOUS LOADS

portional to the armature amperes, even when the brush drop is included. As the speed is proportional to *E*, then the speed should drop off along a straight line as the load is applied. Curves *A* in Figs. 1 and 2 show how the speed is affected when considering the *IR* drop only.

The second factor is the armature distortion. Figure 3 will aid the reader in understanding the manner in which a loaded armature causes a cross magnetizing effect. The current flowing through the armature conductors makes the armature in effect an energized magnet coil having an iron core. The result of this distortion is that, when the motor is loaded, the ampere-turns sending the flux through the air-gap and teeth at one pole tip are the sum of the armature distorting ampere turns at that point and the field ampere turns. At a corresponding position under the other pole tip the ampere-turns sending flux through the air-gap are the field ampere-turns minus the armature distorting ampere turns. At no load there are no distorting ampere-turns and the flux densities at both these places are the same. Suppose the machine was then loaded till the distorting ampere-turns at these places were 1000; then at the one place the density would increase by such an amount as 1000 ampere-turns

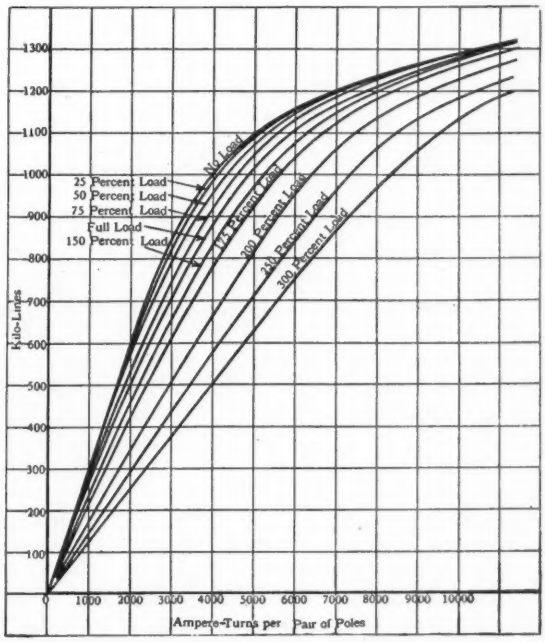


FIG. 5. CURVES SHOWING HOW FLUX VARIES WITH LOAD FOR SEVERAL CONSTANT FIELD EXCITATIONS

would increase it; the density at the other place would decrease by such an amount as 1000 ampere-turns would decrease it.

Due to the shape of the saturation curve an increase of 1000 ampere-turns will not increase the density so much as a decrease of 1000 ampere-turns will decrease it. The result of loading is that the average density of these two points decreases. The same thing happens at all other corresponding pairs of points and the net result is, that as load is applied (the field excitation remaining constant), the armature distortion will cause the flux to decrease. Figure 4 shows the calculated saturation curves of the 10-hp., 500/1500-r.p.m. motor at various loads.

To demonstrate more clearly the effect of armature distortion, the curves of Fig. 5 were drawn from those of Fig. 4. In Fig. 5 is shown how the flux varies with the load for several constant field excitations. In general, as loading begins the flux decreases slowly, as

loading continues it decreases much more rapidly, and finally if loading continues far enough the rate of decrease of flux will diminish. This action is shown best by the 2000 ampere-turn curve of Fig. 5. It should be noted that if the machine is highly saturated armature distortion has but little effect at fractional loads, that the effect begins to appear sooner at very low points on the saturation curve, and that the effect becomes prominent at the lightest loads when the machine is worked at the knee of the saturation curve. The effect of the distortion is then changed by working at different points on the saturation curve. It can also be changed by changing the air-gap. An increase of air-gap decreases the effect of armature distortion while a decrease of gap increases the effect. Curves *B* of Figs. 1 and 2 show the calculated speed, considering only the effect of the *IR* drop and the armature distortion. The difference between curves *A* and *B* represents the effect of the distortion on the speed curve.

The effect of a series field in increasing the field ampere-turns and flux and so in decreasing the speed

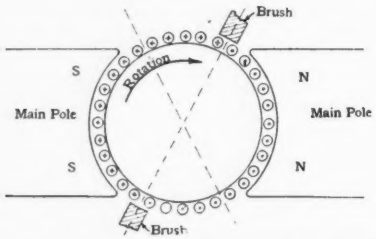


FIG. 6. EFFECT OF SHIFTING THE BRUSHES

is self-evident. The one thing to be noted in a series field action is that it is of far more effect at weak field than when the machine is saturated. Due to the shape of the saturation curve, when any given amount of series ampere-turns are added after the machine is saturated, the increase of flux in lines is less than when the same series ampere-turns are added to the same machine unsaturated. Not only this, but as the flux of the unsaturated machine is not nearly so great as that of the saturated, then even the same change of lines of flux would have a far greater percentage effect on the speed for the unsaturated machine than for the saturated one. Curves *C* of Figs. 1 and 2 show the calculated speed considering only *IR* drop, armature distortion and series field for the motor taken as an example.

Shifting the brushes from neutral primarily gives the same effect as putting a series coil on the machine. In a motor, a shift in the direction of rotation corresponds to putting additive series turns on the field and a shift in the opposite direction corresponds to putting differential series turns on the field. This action can be understood by comparing Fig. 6 showing the brushes shifted in the direction of rotation, with Fig. 3, showing the brushes on neutral. When the brushes are shifted from neutral the conductors between poles on one side of a pole carry current in one direction and those on the other side of the pole carry current in the opposite direction. These conductors act as a series coil around the magnetic circuit of the pole.

There is also a secondary effect of shifting the brushes. When the brushes are on neutral the coils cutting the commutating pole flux are short-circuited by the brush and the voltage induced by this flux is all used up in circulating current under the brush. In a motor the commutating pole next in direction of rotation to a main pole is of the same polarity as that main pole. If the brushes are shifted in the direction of rotation, part of the flux from each commutating pole will cut coils not short-circuited by the brush. The voltage induced in these coils thus helps to form part of the induced voltage. Due to this action, and since the commutating-pole flux varies with the armature current, shifting the brushes gives an effect that increases with the degree of shift, and that is very similar to the action of a series field. The chief difference between this result of brush shift and a series field is that its effect depends not on the saturation of the main pole magnetic circuit, but on the saturation of the commutating pole circuit.

A third effect of shifting the brushes is found. When the brushes are shifted the commutating conditions change, the circulating current under the brushes changes and the resultant series effect of the circulating current changes. Referring to Fig. 7 it will be seen:

1. That the coil undergoing commutation is short-circuited by a brush.
2. That this coil with the brush forms a closed circuit surrounding (or interlinking with) the main pole magnetic circuit.
3. That if commutation conditions are not exactly right, if there is any net voltage induced in this coil, a circulating current will flow through the coil.
4. The effect of this current would be the same as that of a series coil. If the current was in one direction it would correspond to an additive series; if in the other, to a differential series.

For best commutation the circulating current should be kept as low as possible at all loads. Assuming that

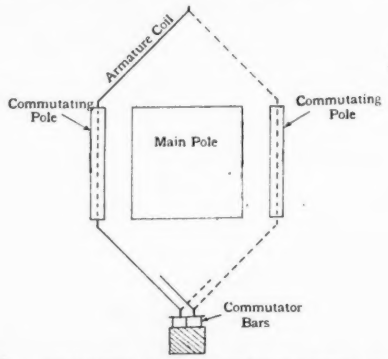


FIG. 7. ARMATURE COIL SHORTCIRCUITED DURING COMMUTATIONS

the coils undergoing commutation are under the commutating poles, the commutating pole flux at all times should be proportional to the armature current. If this ratio is exactly right, there should be no net circulating current around the pole. The only practicable means of exciting the commutating pole circuit is by means of a coil placed on this pole and connected in series with the armature. This makes the commutating pole ampere turns proportional to the armature current. If the commutating pole magnetic circuit were entirely unsaturated, the flux would then be proportional to the

armature current. Since this condition cannot be obtained, a compromise is usually made by making the machine over-compensated (that is, having too much commutating pole flux) at light loads, and under-compensated at overloads.

When a motor is over-compensated, the circulating current has a differential series effect on the main pole flux. When under-compensated it has an additive series effect. This effect would tend then to leave the no-load speed the same, raise the fractional load speeds, leave the speed unaffected at the point of perfect compensation (usually a little over-full load) and drop the speed rather sharply at heavy overloads. As in all series actions, the magnitude of the effect of the circulating current depends on the degree of saturation of the main pole circuit. In an adjustable speed motor, however, this change of effect due to change of saturation is magnified. In this case, instead of the ampere-turns being constant at all field strengths, when unsaturated and at high speed the circulating current is usually increased. One other effect of saturation of the main pole circuit is found on the circulating current. Part of the magnetic circuit on the commutating-pole flux is in common with the main pole flux circuit. When the main pole circuit becomes saturated then to a certain degree that saturation saturates part of the commutating-pole circuit, and tends to make the machine less overcompensated at light loads and more undercompensated at over-loads.

As a result of the various factors, the speed regulation curve is usually found to be very nearly a straight line when the main pole circuit is highly saturated, the commutating-pole circuit is not saturated, and the loads taken are not large. If the reverse of all these conditions is true, the speed regulation curve will be decidedly a curve. It will be concave upward at light loads and concave downward at heavy overloads. The shape of the curve in general would be something like curve *C* in Fig. 2.

When the load is thrown on, the speed of some motors will fluctuate for a considerable time before becoming constant, and on some motors it seems never to settle down. If the ampere load is noted, it is seen to fluctuate as to speed. A motor in which this hunting occurs is called unstable. Such a condition of operation is unsatisfactory. Speed torque curves of the motor and of the driven machine should be plotted on the same sheet. The point of intersection of the two curves is the normal point of their operation. If at this point the two curves very nearly coincide, then the speed and torque are liable to hunt. The motor would then be called unstable. In truth, it would be as fair to call the load unstable, for the action is not a result of the characteristics of either machine, but is the result of the combined characteristics of the two. When motors are built, the characteristics of the machine to be driven are seldom known; however, it can safely be concluded that the torque of the driven machine does not drop as the speed increases, and that an increase of speed is necessary to get an increase of torque. Then if the motor is designed so that at no point on the speed torque curve does the speed rise with increase of torque, it follows that the curve of the driven machine cannot coincide with that of the motor and the set cannot be unstable. The more rapidly the torque of the driven machine increases with speed the more liable is instability to appear. Some motors are unstable at only certain loads, others are unstable at only certain speeds, and still others are unstable over a wide range of speed and loads.

In the design of a motor, it is possible to help make the speed drop by:

1. Making the armature and commutating coil resistance high and the armature ampere-turns low.
2. Making the air-gaps large.
3. Saturating the main pole magnetic circuit.
4. Undercompensating (making the commutating turns too few, or the commutating pole gap too large).
5. Shifting brushes off neutral in the direction of rotation.
6. Adding series turns on the main pole.

If a completed machine is found to be unstable when connected to the load, the first step should be to increase the main bore of the machine till either the maximum gap, mechanically, is reached or until the speed becomes so high that further increase is not permissible. The next step would be to increase the commutating pole bore as far as possible, so long as commutation remains good. The final step would be either to shift brushes in the direction of rotation or to add series coils. If the motor is to be reversible, the required effect must be obtained by addition of series coils. If shifting brushes causes bad commutation, series coils must be used.—The Electric Journal.

Automatic Central Station Control

A PROGRESSIVE step to meet an increased demand for electric power for general lighting and industrial use has been taken by the Ontario Power Co., Ontario, Cal., by the decision to install a remote control automatic waterwheel equipment at a new hydroelectric power station on its system.

The company engages primarily in irrigation work, but by combining the flow of water for this purpose with generating apparatus, it has been able to regulate the flow both in accordance with the irrigation requirements and to create additional electric energy as a by-product.

This power is sold direct to the consumer in the company's territory, or, in the case of a surplus is disposed to other companies serving more remote sections.

The waterwheel in the new station will be controlled from the company's main station 2 mi. distant by a switch actuating a set of contactors which control motor operated needle valves in the waterwheel nozzle. This serves to regulate the amount of water which is allowed to flow through the waterwheel at any time.

This is the second installation of its kind on the company's system. In 1919 power house No. 2 was equipped for similar operation. The new equipment, which has been ordered of the General Electric Co., consists of a 2300-v., 400-kv.a. generator, driven by a Pelton waterwheel with a direct connected 12-kw., 125-v. exciter, an automatic control apparatus as explained above.

REPORT of the National Bureau of the Budget shows a reduction of over a billion and a half dollars in expenditures for the current fiscal year as compared with the last year and nearly a half billion for 1923 as against 1922. Actual reductions for the current year will probably be over two billion dollars.

Power Plant Troubles

IMPROVING EQUIPMENT IN ORDER TO SECURE GREATER RELIABILITY OF OPERATION. BY H. A. JAHNKE

OPERATING ENGINEERS frequently have certain pieces of equipment under their care which requires more or less close attention during the time that the power plant is in operation. The attention given such apparatus is often regarded as routine work and no attempt is made to make any improvements which would decrease the amount of attention required. The time and effort spent in studying the means by which such improvements may be effected will be repaid with compound interest in time saved later on.

In the plant the writer has charge of at the present time, all the condensate from the heating system went to waste day and night for many years, live steam being used at reduced pressure. It is obvious that the amount of steam wasted in this manner during a number of years was enormous. Four or five years ago, however, traps were installed for boiler feeding, and for returning the condensate from the heating system and other steam-using apparatus to the boilers. This is done by a lifting trap which receives the condensate from a receiver and forces it first into a direct return trap and then into the boiler. As the water of condensation is not sufficient for boiler feeding, make-up water has to be supplied to the lifting trap. How the make-up water is supplied to the trap is shown in Fig. 1, where the water runs from the city main into a tank, then into the trap. The amount of make-up water is regulated by the globe valve A. Frequently, however, the regulating valve was opened too wide or the trap would act slower at times and the tank would fill up and run over if not noticed in time by the engineer or fireman. In this way much water was wasted in the course of time, water being paid for at meter rates.

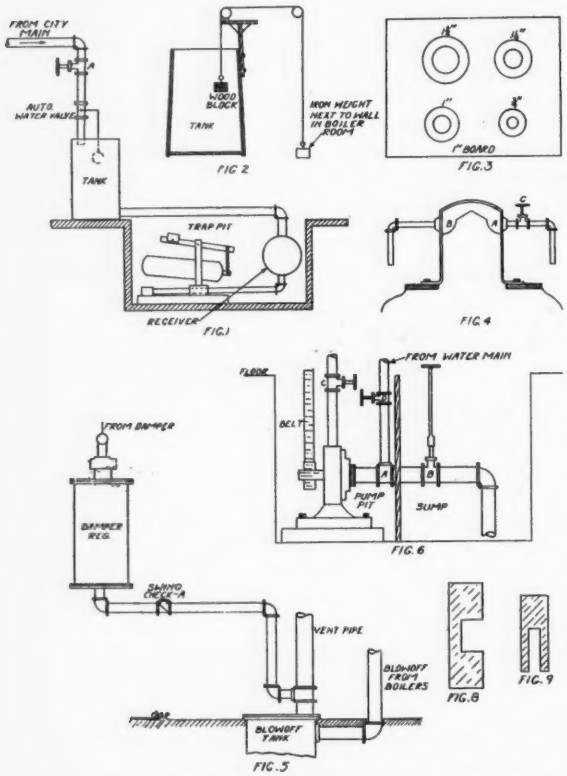


FIG. 1. SHOWING METHOD OF SUPPLYING MAKE-UP WATER TO THE TRAP

FIG. 2. WATER LEVEL INDICATOR PLACED ON SUPPLY TANK

FIG. 3. GASKET GAGE BOARD

FIG. 4. INSTALLATION OF A VALVE REMEDIES OIL TROUBLE

FIG. 5. CHECK VALVE PREVENTS WATER FROM BACKING UP INTO REGULATOR

FIG. 6. CONNECTION TO CITY WATER MAIN AIDS IN CLEARING SUCTION AND DISCHARGE PIPES TO PUMP

FIGS. 8 AND 9. COVERS FOR HOLES IN FURNACE FRONTS

One day while making some repairs I was notified that the trap tank was overflowing again and had been for some time. Right there and then I decided to find some way to regulate the water to the tank automatically. Finally I hit upon the idea of placing an automatic water valve in the water line to the tank as shown in Fig. 1. With this arrangement, when the regulating valve is opened too wide or when the trap acts a little slower than usual and the tank tends to fill up and overflow, the automatic valve shuts off the water, preventing the tank from running over. As soon as the water level falls the valve opens again. In this way no water is wasted and gives less worry and labor to the plant operators.

GAGE ON WATER TANKS

IN ANOTHER instance the water for two large water tanks is regulated by two automatic water valves. These tanks furnish hot water to the plant for manufacturing purposes. Frequently the tanks would overflow or run empty entirely before it was noticed, due to failure of the automatic valves to open or close. This, as a rule, would not be noticed until there was no water in the factory or the tanks were overflowing. In one way water was wasted while in the other way production was stopped in the plant due to shortage of water. In either way money was wasted.

To remedy this trouble I suggested that a gage be placed on the tanks as shown in Fig. 2. The gage was located in the boiler room, making it possible for the engineer or fireman to look at the gage frequently to ascertain the height of the water in the tanks and to note whether the water valves were operating properly. This was an inexpensive arrangement which clearly indicated whether the valves were open or closed by indicating a very high or low water level; hence the valves could be examined before the tanks would run entirely empty or overflow. In this manner the waste of water and loss of production in the plant was avoided.

These conditions had existed in this plant for a number of years and nobody had ever given the matter a thought to improve them.

Gages for Gasket Cutting

In most power plants and in the factory there are a number of pipe unions and flanges in use on which the gaskets must be renewed frequently. In the average plant the steamfitter or engineer cuts the new gaskets after the joint is taken apart so as to obtain the correct size of the gasket. This usually is done by laying the sheet of packing over the union or flange, and marking it with a hammer. To do this, much time is wasted and often we are extremely anxious to get a broken union or flange joint together again.

We have a large number of ½ to 2-in. unions and flanges in the plant and there are always a number of unions that require new gaskets. These gaskets must be renewed quickly so as not to delay the production very long.

While an attempt is made always to have a number of different sized gaskets on hand, it frequently happens that a person taking a gasket from stock fails to cut a new one for future use. In a case of this kind we have installed what we call a gasket gage board. This is shown in Fig. 3. It is made of 1-in. lumber and the different sized gaskets are marked off on it with a compass. Should it be necessary to cut a gasket quickly, the gasket cutter is adjusted to the correct size on the gage board. In this way the gasket is perhaps ready before the joint is disconnected, which means a saving of time over that of cutting the gasket after the joint is disconnected in order to obtain the correct size.

Improving the Flowing of Oil to the Engine Bearing

At one time I had under my charge a high-speed engine which was lubricated by the splash system. I always had trouble due to one of main engine bearings not receiving sufficient oil, especially if the oil in the crank case became a little low. This made it necessary to have the crank case well filled with oil at all times. This condition always was a source of worry as I was afraid that some day the oil would run too low in the crank case and not be noticed in time to prevent the bearing from running dry.

The trouble in this case was that the crank case cover, Fig. 4, was not quite level and more oil ran into the oil pocket A than B. This trouble could not be remedied without much expense, so one day while looking at the engine and bearings, trying to think of a different way to eliminate the trouble I hit upon the idea of placing a cock or valve in the oil pipe from pocket A, as shown at C. By means of this valve I would reduce the flow of oil running through this line onto the bearing which was receiving more oil than necessary. That night, after shutting down, the valve was installed and after starting the engine and adjusting the valve the bearing that had received too much oil received about the right amount. The other bearing also received sufficient oil. After this it was not necessary to carry the oil in the crank case at a high level in order to supply both bearings with oil.

Remedy for Damper Regulator Trouble

A few months ago I installed a steam operated damper regulator. I connected the exhaust pipe from the regulator into the vent pipe of the boiler blowoff tank as shown in Fig. 5. There was no other convenient place to connect the exhaust into, as the exhaust steam contained more or less cylinder oil; otherwise I would have connected it to the condensate receiver of the heating system.

Some time after that I noticed that the regulator operated more slowly than before. At first I thought that the piston was running dry and I gave it more oil, which made the regulator work freely again until the next day, when the same trouble occurred. The regulator would stick and not go back into the opening position. In giving the matter more thought and examining all parts and pipe connections, I came to the conclusion that I made a mistake in connecting the exhaust pipe into the blowoff tank. I concluded that whenever some of the dirty water was blown out of the boiler, which was done each morning and noon, some of this water would back up into the vent pipe of the blowoff tank and exhaust pipe of the regulator and into the cylinder. As soda ash is used as a boiler compound, this would cut the cylinder oil on the regulator cylinder walls and piston, and the regulator would stick or work slower. To prevent the dirty water from entering the regulator I placed a swing check valve in the exhaust line as shown at A, Fig. 5. After this there was no further trouble. A globe valve would have answered the same purpose, but I thought it would have been an easy matter to forget to close the valve when the boilers were blown down.

Kink in Clearing Suction and Discharge Pipes

In a manufacturing plant where a centrifugal pump is in use for draining a sump containing dirty water in which there is much lint and other foreign matter, the discharge and suction pipes would frequently become clogged up, making it necessary to disconnect the pipes at times; in this way, much time was wasted with loss of production.

One day while being in a hurry to drain the sump the discharge pipe got clogged up again and there was danger of the sump overflowing. Then I decided to find some way of clearing the pipes quickly of the foreign matter which I accomplished in the following way: A tee was placed in the suction pipe near the pump as shown at A in Fig. 6. Then a pipe was run from this tee to a connection in the city water main. The valves B and C were also placed in the suction and discharge pipes. Now when the discharge pipe gets clogged up the valve B in the suction is closed and D in the water pipe opened. There is about 60 lb. under pressure in the city main and this usually clears the discharge pipe of any foreign matter. Should the suction pipe get clogged, the valve C in discharge is closed and valve D opened; the water pressure forces the foreign matter back into the sump. In this way the pipes were cleared quickly without much loss of time.

This water pressure also comes in quite handy whenever the pump loses its suction. All that is necessary is to open the valve in the water line for a short time. This forces all air out of the pump and suction is started again.

Someone may ask why a strainer or screen was not placed over the inlet opening of the suction pipe or sump. I had done this, but, due to the fact that the water contained so much lint and other matter, it kept one busy most of the time cleaning the strainer or screen

and it was less trouble to let the matter pass through the pump.

Closing Up Draft Holes in Boiler Front

In a power plant where it was necessary to keep a slow fire under the boilers, nights and Sundays, to furnish steam for the heating system in the factory, hand operated stokers were in use. The man installing the stoker had cut the holes in the boiler front through which the bars that operate the stoker and dumping bars pass quite large, as shown in Fig. 7 at A, B, C, D. Much draft would pass through these holes when the draft doors were closed, causing the fire to burn quite bright, when a slow fire was wanted at nights and on Sundays. In this way, much coal was wasted and the fires would burn out too quickly at times, due to lack of fuel.

To remedy this trouble, covers were made out of heavy sheet iron as shown in Figs. 8 and 9. The cover

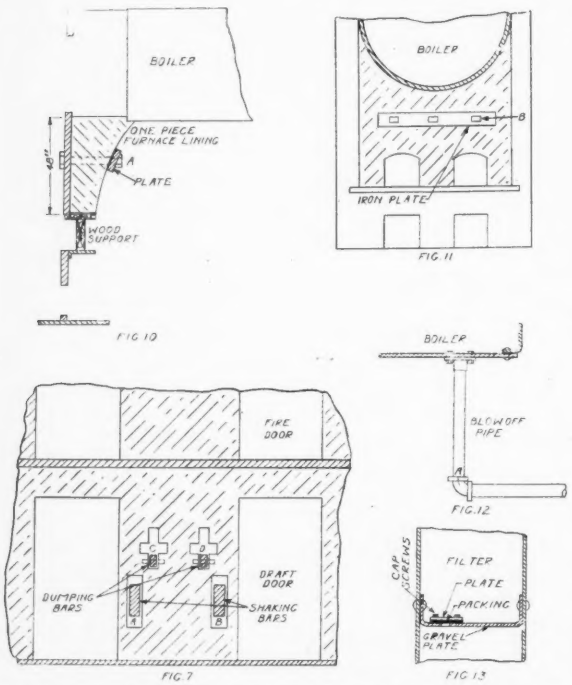


FIG. 7. FURNACE FRONTS SHOWING LARGE HOLES THROUGH WHICH OPERATING RODS PASS

FIGS. 10 AND 11. FRONT ARCH AND ONE-PIECE FURNACE LINING

FIG. 12. SHOWING CRACKED ELBOW IN BLOWOFF PIPE

FIG. 13. REPAIR OF FILTER

shown in Fig. 8 fits over the holes and operating bars, A, B, one cover for each hole, while the cover in Fig. 9 fits over the holes C, D. In this way the holes are covered up each night after the engine is shut down and Sundays. Less coal is used and the fires do not burn out as quickly as before.

Supporting One-Piece Furnace Lining

Last summer I installed in the boiler furnace a plastic or one-piece furnace lining. As the boiler is set about 48 in. from the grate, I was in doubt whether the front arch over the door opening could be held in place with the wood supports alone until the lining was dried out with a slow fire. The front arch and one-piece furnace lining is shown in Figs. 10 and 11.

To make certain that the lining would not come down before being dried out and capable of supporting itself, I drilled four ½-in. holes through the boiler front, then placed an iron bar across the lining about midway between the boiler and grate. This plate was held in place with four ½-in. bolts passing through lining and boiler front as shown at A and B. I had no trouble with the lining coming down, and it took about four weeks before this iron plate was burned away from the lining.

Does It Pay to Inspect Your Equipment?

At one time, while having charge of a plant consisting of two large boilers, one of the boilers was not in operation for a few days and I thought this would be a good opportunity to inspect it and give it a cleaning. While it was cooled off I ordered one of the helpers first to clean the ashes out of the combustion chamber. He had not been in the combustion chamber long when he reported that there was a leak around the blowoff pipe, as he felt water dripping on him. After the combustion chamber was cleaned, I made an inspection and found that the elbow was cracked as shown at A in Fig. 12. This was a puzzle to me, as the blowoff had been renewed only a short time before; there was no scale in the elbow and pipe and no strain at any point. The elbow was replaced.

This shows that we must inspect and look for trouble with any of the equipment under our charge whether new or old.

Closing the Hole in Water Filter

I had noticed for some time that sand was leaking out of our water filter, so at the first opportunity I had all the sand and gravel removed from the filter and made an inspection. I found a small hole in the gravel plate of the filter for which I could not account but decided that a small hole had been drilled into the plate for some reason when it was made and no attempt had been made to plug up this hole again. In course of time the water, sand, and gravel passing through the hole had enlarged it considerably.

As I had no drill and tap on hand to enlarge the hole to fit some size of pipe plug and as the filter was needed badly by that time, I made a quick repair as follows: I drilled two holes next to the hole and tapped these for ⅜-in. cap screws. Over the hole I placed a piece of sheet packing and on top of that an iron plate through which two holes were drilled. Cap screws through these holes served to hold the plate in place as shown in Fig. 13. This effectively prevented further leakage.

At the Pittsburgh Experiment Station, in connection with the investigation of coal storage problems, coal has been exposed to excess air for three hours at 150 deg. C.; the amount of oxidation products formed and the amount of oxygen absorbed are taken as a measure of the tendency of the coal to ignite spontaneously. The method has been tested on Newfield (Freeport) coal and Texas lignite with fairly consistent results.

Developments in Use of Unaflow Steam Engines

REVIEW OF SECOND ENGLISH EDITION OF STUMPF'S BOOK POINTING OUT PROGRESS MADE IN DESIGN AND APPLICATION OF UNAFLOW ENGINES. BY C. C. TRUMP

THE NEW edition of Professor Stumpf's book in English is something more than a translation of his new German edition and, as stated in his preface, represents a complete revision of the first one. That he has been following consistently a logical development is illustrated by the similarity between the original sketch of a unaflow engine made by him in the year 1900 and the drawings of his latest design as it appears in the Preface.

Stumpf states that the losses in a steam engine may be classified as follows:

1. Losses due to cylinder condensation (surface loss).
2. Losses due to the volume of the clearance space (clearance volume loss).
3. Loss due to throttling or wiredrawing.
4. Friction loss.
5. Loss due to leakage.
6. Loss due to heat radiation and convection.
7. Loss due to incomplete expansion.

He then sets out to show how his design of unaflow engine may be adapted to reducing all of these losses to a minimum and thereby improve the performance of the reciprocating steam engine to a point where it makes possible in the small plant efficiencies as good as those obtained by the largest steam turbines.

Machining all of the inside surfaces of the steam cylinder is recommended and further means of reducing surface loss are jacketing, compounding, superheating and the unaflow system. "The unaflow principle," he says, "permits the use of the single cylinder single-stage expansion engine for this service, since the unidirectional flow of steam eliminates initial condensation despite the fact that a part of the cycle takes place in the saturated region. The unaflow principle is also of great advantage for non-condensing and multi-stage engines."

Points of design as they affect mechanical efficiency and the reduction of losses due to friction are taken up, giving some dimensions from the designs of Sulzer Brothers. Stumpf favors the American type of packing in certain respects and recommends that they be made very much like good gas engine rod packings and provided with means for lubrication with oil suitable for the maximum steam temperatures. This is particularly important in condensing engines, as a rod packing not sealed with oil or water is apt to cause leakage of air into the condensing system.

One of the most striking parts of the new edition gives results of Professor Naegel's experiments on the measurement of temperatures in a unaflow cylinder. "The remarkable feature about the temperature change of the working steam is the fact that at the end of compression the latter attains temperatures of such a magnitude as were hitherto thought impossible. A terminal compression temperature of about 500 deg. was observed when running with saturated steam of 10 atmospheres gage."

PROGRESS IN MANUFACTURE

BETWEEN 1908 and 1920 there were built in Europe over three-quarters of a million horsepower in these engines. Professor Stumpf states in one of his recent letters that in one plant near Merseburg there are 59 unaflow engines of about 1000 hp. each. In the United States, between 1912 and 1920, there were built over 200,000 hp., mostly by two licensees. At the present time there are a dozen licensees, of whom perhaps six or eight are actively selling engines of this general type. The growth of the unaflow engine business has been more rapid even than the Diesel engine and compares favorably with all other types of prime movers with respect to its rapid progress.

The Corliss unaflow engine, of which a few were built in the United States, is described. This type has practically been discontinued because it is not well adapted to high pressures, temperatures, or speeds.

One chapter deals with unaflow engines arranged for bleeding, or taking off steam during expansion after it has done some work in the cylinder. While this chapter does not contain much new matter, the subject seems to be one of importance especially for textile plants and other places in chemical industries where a small amount of steam is needed for process work, as compared with the amount of power required. This chapter shows that the unaflow engine is equally well adapted to this kind of service when compared with a turbine.

Ehrhardt & Sehmer are mentioned as originators of most of the designs of unaflow rolling mill engines shown, both for flywheel and reversing type engines. So far as known, no unaflow engine of the reversing type for rolling mills has yet been built, although several designs have been made. The two largest engines which are known to be in operation are one 67-in. diameter by 55-in. stroke, built by Ehrhardt & Sehmer, and another 60 in. diameter by 71-in. stroke, built by Galloways, Ltd., of England. A still larger engine, 76-in. bore by 72-in. stroke has been designed for a rolling mill in the United States by the Mesta Machine Co., of Pittsburgh. The Mesta Machine Co. has installed a 40 by 48-in. rolling mill engine at one of the Pittsburgh plants of the American Sheet & Tin Plate Co., and two engines of similar size were installed by Nordberg Manufacturing Co., at Youngstown Sheet & Tube Co., one 44 by 50-in., and another 37 by 48-in., also two engines 24 by 42-in. for Whitaker Glessner Co., Wheeling, W. Va.

The unaflow engine requires considerably less space than a tandem compound for this service and has a lower water rate, especially over the whole range of variable load and during the extended periods of idling. Professor Stumpf shows that the adaptation to reversing service is only a matter of careful design of valve gear and of pistons, crossheads and other reciprocating parts. For copper plants and steel mills where waste heat boilers are used on furnaces, the unaflow engine would seem to offer an economical solution of the rolling mill and other power problems.

Drives for Compressors and Pump

Under the heading, "Unaflow Engines for Driving Air Compressors, Pumps, etc.," the new edition shows several novel designs, including a high speed pumping engine built by Worthington Pump & Machinery Corp., of New York City, after the designs of their Mr. Decrow, of the Snow-Holly Works, Buffalo.

By the use of a special water valve Mr. Decrow is able to run at plunger speeds three or four times as high as previously considered practical. This allows the use of economical piston speeds in relatively small unaflow cylinders. The governor operates directly on a sliding cam shaft to control the cutoff by means of taper cams operating the proper valves. All the valve gear and even the flywheel is cased so that the water works engineer not accustomed to high-speed machinery might not be overcome by the high speed. Tests of this engine at the Buffalo pumping station, where the unit was set up for a convention of water works engineers alongside of a large triple expansion pumping engine, showed a remarkably high duty.

Another novel feature is the application of the unaflow cylinder to a high speed reciprocating tube pump, which is the subject of a patent to Trump and Frederichs of the Humphrey Gas Pump Co. This machine was developed in response to a demand for a simple and economical pumping engine for irrigation from wells in the southwest of the United States. It is remarkable in that it applies an expansive heat cycle to a direct acting pumping unit without a flywheel. It is a dynamic development of the old sand pump used by well diggers, and mechanically may be classified between a reciprocating plunger pump and a centrifugal pump. The flow through the tube having only one set of valves at the bottom, and hung directly on the rod of a power piston, is very nearly continuous. The machine has been developed to operate with a Diesel oil power cylinder as well as with a unaflow steam cylinder.

Other compressors using unaflow cylinders have been designed and built in the United States and it is unfortunate that Professor Stumpf did not have data regarding these for his book. A paper regarding one of these operating an ammonia compressor was recently presented by Mr. Fairbanks at the annual meeting of the American Society of Refrigerating Engineers. A number of other compressors for different services have been built and tested by the Worthington Corporation.

Locomotive Application

In the unaflow locomotive practically all of the development so far has been in Europe. Possibly a central exhaust engine has been adapted to one or two locomotives in the United States, but none seems to have been built with full knowledge of Professor Stumpf's designs.

By replacing the large number of exhaust ports by one or two nozzles, Professor Stumpf has been able to reduce the length and diameter of his cylinder for a given power and at the same time reduce the clearance volume losses and improve the water rate. He has been making tests on a locomotive built for the German State Railways in 1920, by A. Borsig, of Berlin, from his own designs. Although he was not at first successful in obtaining much reduction of back pressure in his cylinders, more recent tests have shown that he can obtain 0.5 atmosphere = 7.1 lb. per sq. in. = 14.2 in. mercury in the exhaust pipe; and about 0.3 atmosphere = 4 lb. per sq. in. = 8 in. mercury vacuum in his cylinder. This vacuum is better with the longer cutoffs and instead of the back pressure increasing with the load, as is the case in a counterflow engine, this locomotive obtains a large indicator diagram not only due to increased cutoff but also due to less compression.

A second nozzle is used with each cylinder to take off steam for heating feed water, or in passenger service, for heating the cars, thereby utilizing steam from which some work has been taken rather than live steam. In addition to this ejector action Professor Stumpf shows a simple, single beat, poppet valve design which is adaptable to the highest economical superheat now used in locomotives.

"The future line of progress of the locomotive is therefore clear. It leads naturally from the two cylinder to the three cylinder engine with unaflow cylinders having small clearance volumes, to the use of single beat poppet valves and the utilization of the ejector action of the exhaust, in combination with high pressures and moderate superheat."

The unaflow locomobile and portable engine is described at length as in his early edition. He has added, however, a direct comparison between his previous design and the new one with the ejector nozzle exhaust. It will be seen that the circle of exhaust ports has been replaced by a single slot lengthwise in the cylinder wall and leading into a nozzle opening into the exhaust pipe. With an exhaust pipe of the proper length, a single-cylinder engine can be made to utilize the energy in the exhaust nearly as well as a multi-cylinder engine. It will be seen that the piston and cylinder length are reduced by about 20 per cent. The power and overload capacity is probably actually increased. The cylinder design is simplified so that only one support is required and the mounting of such a cylinder on a portable boiler becomes an easy matter.

A design of a V type, four-cylinder, single-acting, unaflow engine for automotive purposes is shown as designed by the Stumpf Una-Flow Engine Co., Inc., Syracuse, N. Y., for a light truck or passenger car. Similar engines were designed, built and tested in a motor truck and also in a high pressure steam tractor. The application of the ejector exhaust principle to this type of engine might further assist in their development, which during the war was greatly retarded. Engines of the V type require only one cam shaft to operate valves for all four cylinders. The design shown was fitted with two cam shafts in order to make the cylinders as low as possible. It is unfortunate that Professor Stumpf did not have more data regarding automotive work with his engines, as the success which steam traction has had in England and the growing tendency in this country toward limitation of axle loads to prevent damage to our highways, would indicate the advantage of an economical steam engine unit for motor truck and tractor service. The development of the exhaust ejector action as described in this chapter would seem to be of assistance in this direction.

Use on Ships

In the chapter on the unaflow marine engine is an illustration and description of a design of tug boat

engine which was built for the Lake Champlain Navigation Co. by the Kingsford Foundry & Machine Works, in the United States. Also designs of two single-acting, high-pressure engines, one made with a sliding cam shaft with taper cams and the other with Professor Stumpf's new double speed valve gear for high lift, single-beat poppet valves. These are in addition to designs of a single-acting, condensing marine engine by Schmid, previously described in the German technical papers. The unaflow marine engine development had not progressed far enough at the beginning of the war to be considered by the marine designers as standard practice to be embodied in the large number of engines built for the Emergency Fleet. This was unfortunate, as there are now available a large number of triple expansion marine engines which it will hardly pay to fit with unaflow cylinders. A three-cylinder unaflow engine will show fully as good water rate as a triple expansion engine and probably better on variable loads. It is more compact, more easily reversible, being especially positive due to absence of receiver troubles, and is particularly well fitted to ferry boat, tug boat or barge canal service. It would seem that barges hauling coal could hardly afford to burn oil where a well designed boiler plant and engine can be bought at about the same price per horsepower and should show a fuel cost considerably lower than the best oil engine. For ferry boats the unaflow engine has the same advantage as for rolling mills in that it has the lowest possible water rate when idling. As Professor Stumpf concludes, the two or three cylinder unaflow engine offers special advantages for marine service:

"By distributing the steam flow to several cylinders, smaller inlet valve dimensions are obtained, in contrast to the bulky valves necessary with multi-stage engines, in which the total working steam has to pass from one cylinder to the next in series.

"Another valuable feature of the unaflow marine engine is the small number of spare parts required, since each of them may be used with any one of the cylinder units."

In his last chapter Professor Stumpf takes up his novel design of single beat valves and double speed lay shaft, with various modifications. Probably everybody will agree with Professor Stumpf on the desirable simplicity of the single beat poppet valve. The object of his design is to provide a valve gear which will give a single beat valve high enough lift with the short cutoffs used in a high pressure condensing unaflow engine to prevent heavy throttling losses. The mechanical device of combining two eccentrics running at different speeds to obtain these results is clever enough. By increasing the speed of his main lay shaft, the size of his governor may also be reduced. Whether or not there will be sufficient demand for an engine to operate on high steam pressures and fine vacuums, for which this design seems especially suited, will, in this country, depend largely upon the rising importance of the cost of fuel. There is no doubt that the tendency is now in this direction. There are few plants, however, where the cost of fuel represents more than 15 per cent of the total cost of operation, so that it will require more than a few per cent saving in fuel to justify an engine with any valve gear complications which will add materially to its first cost. The practical application of Professor Stumpf's clever design, therefore, rests with the future.

Supporting Structure for Fuel Oil Tank

DETAILS OF CONSTRUCTION AND METHOD OF CALCULATING STRENGTH OF MEMBERS. BY F. W. BRADY

IT WAS necessary to make a 10-ft. steel supporting structure for a fuel oil tank of 3000 gal. capacity. Some structural steel discard was available for the structure and it was proposed to make the tower as shown in Fig. 1. The problem was how to figure the loads on the different members so as to get the proper sizes of the steel to use; that is, to check over the work from an engineering point of view. As this kind of work may be of interest to some of your readers, the problem is given in full below.

Fuel oil weighs about 7 lb. per gal., so that the load on the tower, exclusive of the tank, floor, etc., is $3000 \times 7 = 21{,}000$ lb., or a little over 10 T. It was proposed to make the tank 6 ft. high. In this case its diameter would be 9 ft., which is calculated as follows:

One gallon contains 231 cu. in. Therefore, the tank capacity is $231 \times 3000 \div 1728 = 401$ cu. ft. If the tank is 6 ft. high, then the area of the bottom is $401 \div 6 = 66.66$ sq. ft. $= 0.7854D^2$, or $D^2 = 66.66 \div 0.7854 = 85$, or D = approximately 9 ft. It was decided to make the tank 7 ft. high and 9 ft. in diameter.

The structure was made 10 ft. square at the top and 12 ft. square at the bottom. Each corner post rests on a concrete base 2 ft. square at the bottom and 1 ft. square at the top and 2 ft. deep. The posts were made of 5 by 5 by ¾-in. equal angles, the top members of 8 by 2.425 by 0.395-in. channels, the braces around the middle of 2½ by 2½ by ¼-in. equal angles, and the cross braces of 3 by 3 by ¼-in. equal angles. The foot plates were 12-in. pieces of 5 by 5 by ½-in. equal angles. The ends of each top member have two ¾-in. bolts, the cross braces and horizontal braces have one ¾-in. bolt, and the bottom of the corner columns has two ¾-in. bolts. Each column has four bolts at the top, two in each branch. Figure 2 shows the design of the joints. The floor is made of 3-in. pine spiked to stringers bolted to the channels as shown. To calculate the strengths of beams and columns requires the use of two important formulas:

$$M = \frac{S\,I}{c} \text{ for beams, and}$$

$$P = 16{,}000 - 70\,\frac{l}{r} \text{ for columns.}$$

In these formulas, S is the greatest stress per square inch allowed in the member, which is usually taken at 16,000 lb. in beams; P is the total load on a column; A is the area in square inches of the cross section of a member; l is the length of the member in inches; M is the greatest bending or breaking moment of the load, which for a beam with its load uniformly distributed

along its length is $\frac{Wl}{8}$, where W is the total distributed load; I is called the moment of inertia of the beam or column, and r is its radius of gyration. Both of these terms are explained later in connection with the use of the formulas; and c is the distance from the lower edge of the beam up to its neutral plane. It should be understood that a loaded beam is stretched at the bottom and compressed at the top. Then there is a neutral plane somewhere between the top and the bottom that is neither pulled nor pressed.

The greatest load on any one of the top members of the tower is half the load, or about 10,500 lb. This load includes the floor, the tank, and the oil. Though this load is not uniformly distributed along the length

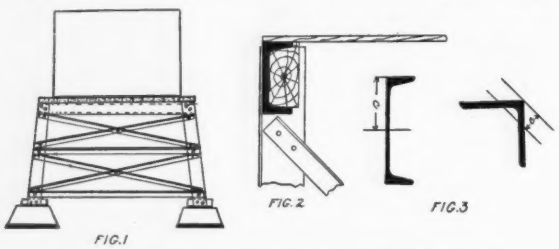


FIG. 1. STEEL TOWER FOR 3000-GAL. OIL TANK
FIG. 2. CORNER JOINTS FOR STEEL TOWER
FIG. 3. CHANNEL AND EQUAL ANGLE ROLLED SHAPES

of the supporting beam, the calculations can be made on this basis with safety. By the first formula

$$\frac{I}{c} = \frac{10{,}500 \times 10 \times 12}{8 \times 16{,}000} = 10 \text{ approximately.}$$

The term $\frac{I}{c}$ is called the section modulus. It is the moment of inertia of the beam divided by the distance that the extreme fiber is from the neutral axis. In mechanical handbooks, the values of $\frac{I}{c}$ are given in tables for all the standard rolled steel shapes. Therefore, after getting the value of $\frac{I}{c}$ from the formula as above, all that is necessary is to refer to the tables and select a beam having this value. Thus, if $\frac{I}{c} = 10$, the table shows that a 6-in. channel set on edge and weighing 18 lb. per ft. with a 3.5-in. flange, and a 0.375-in. web will do. Also there could be used an 8-in. channel with a 2.425-in. flange, a 0.395-in. web, and weighing 16.25 lb. per ft.

The deflection of a beam should not exceed $\frac{1}{360}$ of the span, or in this case $10 \times 12 \div 360 = \frac{1}{3}$ in. The span limit in feet for steel beams is taken as twice the depth of the beam in inches. In this case, we have $2 \times 6 = 12$ ft. as the greatest span for which a 6-in. channel should be used. This value indicates that for a span of 10 ft. the 6-in. channel is safe. The tables in the handbook give 1.655 as the coefficient of deflection for a distributed load over a 10-ft. beam with a maximum fiber stress of 16,000 lb. Then, 1.655 ÷ 6 gives 0.276 in. as the possible deflection. As the allowable deflection is 0.3 in., this beam appears to be safe from this standpoint.

Columns

Where a column has a length greater than 10 times its least diameter, the load tends to bend the column at the middle. This action is similar to that of a load on a horizontal beam. If the column is not circular it will bend in the direction of its shortest sectional line. Therefore, the moment of inertia I of a column must be taken in the direction of its greatest weakness; that is, sidewise instead of edgewise. The handbook tables give these least values which are used when calculating the strength of columns.

The term $\frac{l}{r}$ in the formula for columns is called the ratio of slenderness. Its value should not exceed 120 for columns and 200 for braces. The radius of gyration r has a value equal to I ÷ A; that is, the least moment of inertia of the section of the beam divided by its area.

The formula for columns as previously stated is $P = 16{,}000 - 70\frac{l}{r}$. A value much used for $\frac{l}{r}$ is 100. The load on each column is $\frac{2100}{4} = 525$ lb. Therefore, $P = 16{,}000 - (70 \times 100) = 9000$ lb. As $l = 120$, and $\frac{l}{r} = 100$, then $r = 100 \div 120 = 0.83$. An equal angle having this value of r is 5 by 5 by ¾ in. It should be noted that for an equal angle that is used for a column its least tendency to resist bending is cornerwise. Therefore, the value of c is taken on the diagonal and the least value of r is based on this axis. See Fig. 3. The ties forming the square at the foot of the column could be 2½ by 2½ by ¼-in. equal angles, though a lighter section would be amply strong. It should be noted, however, that these ties are very liable to be stepped on or to receive loads, applied either accidentally or purposely. Therefore, if a heavy angle, even one as great as that used for the columns, is available, this could be used to good advantage. The cross braces may be 3 by 3 by ¼-in. equal angles, and the ties forming the square at the mid-height may be 2 by 2 by ¼-in. equal angles, or greater, depending upon the sizes on hand.

The rivet holes weaken the members so that these holes should not be over ¾-in. In fact ⅝-in. holes would likely give ample strength. The allowable shear is 12,000 lb. per sq. in. The area of a ¾-in. bolt is 0.44 sq. in., therefore this bolt will take a load with safety of $12{,}000 \times 0.44 = 5280$ lb. As this is one-quarter the load on the tower, and as this load is carried by at least four such bolts, it is seen that the size is really larger than necessary, and that ⅝-in. size could be used.

All the members should receive a good coat of red lead and oil before being erected. This coating is specially needed in all the joints which will rust out quickly if not thoroughly protected. After the tower is erected, give the entire structure a coat of weather-proof paint.

Trouble Hunting---XIV

BUILDING PUMPS FROM MATERIAL IN THE SCRAP HEAP IS FOUND TO BE AN ECONOMICAL AS WELL AS INTERESTING PASTIME. BY JOHN PIERCE

IN MIXING mortar for the walls, I learned how the Mexicans mix mortar. It was certainly a new one on me, though it may be a good way. They just air-slack their lime, then mix the sand and lime together, wet, on the ground, heap it in a great pile and let it lie that way for from ten days to two weeks. After that time it is considered "ripe" and ready to use, and they dig it apart, wetting it as they use it.

We first moved an old Scotch Maine boiler into place, built cradles under her at either end and set her up. This boiler was in very bad shape as regards scale, and I ran the hammer through her flues and certainly took out a load of it. As soon as she was up we gave her a number, which was, naturally, number one. Number two was brought up and lined up some 16 ft. from number one, as I was intending using the space between these two boilers for my pump room. I had a lot of trouble with this boiler before I got mad and fixed her right. She had the oldfashioned mud drum below, and on top a steam drum nearly as big as the boiler itself. I didn't have the room for the steam drum as my house, which had been built before I came on the job, was not high enough. So I took the steam drum off and discarded it. The mud drum didn't suit me, so I took that off also. The main reason for taking this off was fear.

While the firemen on the boiler then under steam did, as I have said, blow down, apparently, every two hours, I still was doubtful about their continuing to do so, and I knew that once they did not blow down for several hours, or for a day. This drum would fill with precipitate and then burn. Once it burned and ruptured, I knew there would be "trouble" and not the kind of trouble I was hunting, for if anyone should get killed or hurt with it, as soon after the other one going up, there would be nothing left for me to do but to keep ahead of the bunch—and they can run to beat the thunder too. So I took off the mud drum and pushed down to a 2-in. blowoff. I was afraid this would burn, as had the blowoff at my other job, but I could do nothing else at the time that I could see, for by the time I'd pushed down and plugged there would have been found a very nice bag made of cast iron, right where it shouldn't be.

Later on I found that my blowoff did burn; not only burned but ruptured, and emptied the boiler in no time. Luckily nobody was hurt. I was present when it happened. The boiler had been blown down perhaps 10 min. prior to its burning, and there must have been a rush of the mud to that point, filling it up again at once, and then baking and burning. I can account for it in no other way. I cut a hole in the sheet at once and put on a patch, doing away with the cast-iron flange or saddle that was on the boiler. In this patch I cut a hole and riveted on a malleable iron flange tapped for a 2-in. pipe. I then fed this boiler through the blowoff. That ended the trouble as far as a burned blowoff pipe was concerned.

Number three had no mud drum but did have a steam drum. I took her steam drum down and got her in position without any trouble. Number four was a much larger boiler than any of the others, but she was soon set up. I ran a header of 8-in. pipe and connected the boiler lines into it. I had, at first, only one stop valve to each boiler, but I soon had to change this, for I found that unless I personally cut in the new boiler on the header, when the plant had been idle a day or two, the valves on the other boiler went bad. This looked to me to be very strange and I watched my head fireman when he cut one in, without his knowing that I was watching. He simply went up on the boiler to be cut in and opened the valve, and opened it wide without lingering over the operation; and once the line had cooled and filled with condensation there would be enough water to set up a water hammer which would break the valve. Putting the two of them on helped only in this way. It was explained that water hammer caused the damage and why. With two valves I would make him open one a turn, then the other, and continued so until both were open. That ended broken valves by water hammer.

The boiler up, the steam line was run to the compressor. One of the superintendents was an advocate of the air lift. The other wanted to rig up the big hoist and bail it out. The compressor being ready, we prepared to start up, as I had got the air lift in shape some time previous to this. So we fired up two boilers and got all ready; turning on the steam, old lady compressor started out fine. Well, she did all right until the air pressure went up to 80 lb., when she began to drop her governor and slow down. At 100 lb. she was running only at half speed, and with the ¾-in. line of steam to the low pressure side wide open. I had not looked into the matter until that. Frankly I had hardly given it a thought, but I did now, and found she was built for 150 lb. steam pressure. I could see only one way to operate it satisfactorily and that was, to get new or other boilers that would give me the desired pressure. The boss, or rather one of them, said figure out *some* way to do it until other boilers could be secured. The other boss was well *pleased* with conditions.

I proceeded to cut in a 2-in. steam line to the low-pressure side, added the third boiler, and started her again. This time she held her speed and did the work, but she surely did use an amazing lot of steam in doing it. The Westinghouse by now was ready to go back to its old foundations, and we proceeded to set her up and line up the two machines. The boss wanted to cut her in on the line and help make that much more headway with the water, but I knew from experience that this old sister required her 150 lb. of steam and required it with regularity. So I gave the boss a lecture on steam engines and their peculiarities and told him he'd have to wait. "Till when?" says he. "Till we get new boilers," says I. So he was forced to do so, though he did want to get a pulley small enough that the engine would run at speed with the present pressure, though the compressor ran at only 40 per cent her rated speed.

The next serious problem was water for the boilers. There were millions and millions of gallons of water in the mine, but it was worse than pure acid. Sheets of half-inch boiler steel laid where this water could

drip on it a drop at a time from a height of 4 or 5 ft. at a time would have a hole through them in less than a week. The hotter it was the stronger it seemed to be. We had a little seep where the water seeped from the mountain about half a mile away. Thinking, perhaps, it might open up a stream, I had my men cut and blast away into the rock but no more water could be induced to flow. Then I walled, or dammed up, the end of the cut I made, and we found that every two days we could collect 8000 gal. at this place. Above the main works was another one of about the same strength. So I wanted to run a pipe line to these two places and run their water to a pair of large stone tanks above the plant, in order to help out on the fresh water for the boilers. As I have already said that the rebels had blown up the dam and mined the lake, the reader will not wonder where they had formerly got water to operate the old plant. At this time we had had no rains for 7 mo. and the springs were hardly flowing.

After getting the two springs to flowing to the tanks, I decided to go down in a shallow shaft and investigate. This shaft was only 140 ft. deep, was located near the main plant, and did not connect with the main mine at all. In fact, it had two drifts running from it at the bottom that extended only about 90 ft. each way; and one of the men told me that while the water was no good, it was quite different from the water in the mine. Upon investigation, I found this water to be drinkable if one was not particular about alkali. It was rotten with it, but did not contain the elements the other did, so I rigged up a pump—a Cameron sinker—and hung it on a cable down the well. I used this to pump the water down to its foot valve, and at that point placed timbers across the shaft, testing on the "sets" and mounted a duplex pump at that station. I then ran my pipe line to the tanks and found, on trying out the pumps, that I could secure 14,000 gal. of water a day of 24 hr. there.

Then down the main working shaft I built a set of tanks at the water level. This was a four-compartment shaft, and the water seeping in from above was fairly good water. By nailing cleats around the edge of the shaft on the sets all the way down, and so arranging my little "spill ways," I found I could collect another 8000 gal. each 24 hr. from this place. When we had driven the water down below the 250-ft. level, I moved this pump on down to this point, built new tanks, and made a permanent job of it. The reason for making it permanent was that from the 250-ft. level the water changed and could not be used. These three pumps which I used were pumps which had been discarded formerly, or had been destroyed by the rebels and thrown in their mountain of junk. The Cameron had both been thrown away, and I don't know how many pumps went into their making. I found the steam cylinders in one place, the valve chambers I took from other old discarded pumps, the piston and plungers from others, and I made, after lots of tuning and fitting in the shops, two dandy good pumps that worked like new. The duplex was only a question of looking for and finding the pieces and fitting them together. The valves were, of course, lost and I had to make valves for them by taking old ones that had been used, and that were much too large, but with enough good stock so that they could be turned in the lathe and shaped up for these pumps. The hole in the center gave some trouble and I tried babbit in them, but it would not hold very well, so I finally turned the holes out true and made babbit spools through which I slipped the valve studs and let the valve work on the spools. Of course there was a little leakage, but it could not be helped.

I did not want to pull my pumps every time we stopped the boilers, and I did not want the boilers to run when we had no water, so I rigged up a deep well pump for the 140-ft. shaft, and after we got this installed we could shut down any length of time and not have our pump drowned on us. I hunted up an old Cameron sinker and removed the steam cylinder. Then I found a valve chamber and bolted that onto the water end of the Cameron. I bolted a pair of homemade guides on the place where the steam cylinder had been, found a very good plunger and turned it down to a good true surface. Then we fitted a crosshead to the end of the piston rod and swung her down the shaft, bolting her to timbers on the side of the shaft. Up the shaft we fastened guides for the pitman, and made a 2-in. square rod for the pitman's rod. At the upper end we made a very good job of another crosshead and connecting rod. Then came the rub. We had no crank. But we didn't let a little thing like that bother us. I hunted out a piece of shafting from the old mill which we were tearing down and we went to the blacksmith shop and forged out a good "center crank" crank shaft. This we finished on the lathe, and I venture to say nobody ever saw a better one. Building a set of frames from 8 by 12 timber, we mounted our crank shaft and counter shaft and motor. It had a little gasoline engine, so that when we had no steam we could pump by gas. That ended our worry for that particular place and we hunted up other worlds to conquer.

A BILL WAS recently introduced in the United States Senate which provides that the Government of the United States join with the Government of the Dominion of Canada in the construction of the proposed St. Lawrence River improvement and that the Dominion of Canada cede to the United States the territory lying between the Richelieu River, Lake Champlain, and the Northern boundary of the State of New York, including the bank and bed of the St. Lawrence River to the center of the channel thereof, from the point of intersection with the northern boundary of New York to the mouth of the Richelieu River, in order that the United States may become joint owner with the Dominion of Canada of the course of the St. Lawrence River to the head of the of tidewater below the city of Montreal, and joint owner with the Dominion of Canada in the proposed canals, channels, dams, locks, and hydraulic works, and all rights of navigation and water power appurtenant thereto.

PROFESSOR: What is ordinarily used as a conductor of electricity?

Senior: Why, er-r—

Professor: Correct. Now tell me, what is the unit of electric power?

Senior: The what, sir?

Professor: That will do; very good.—Stevens Tech. Stone Mill.

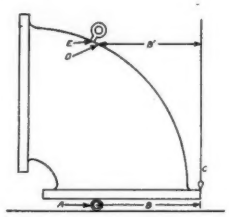
Finding the Center of Gravity of an Elbow Casting

WE HAVE a Curtis turbine in our plant which exhausts at the top, through a 30-in. cast-iron elbow, to the condenser which is located on the same floor.

Whenever we wish to raise the turbine casing for inspection or repairs, it is first necessary to disconnect this elbow and take it down. In the past we have been handling it with rope slings and a chain tackle, but it is an awkward thing to handle with ropes, as they always slip to the high side, causing it to be unbalanced. As we have very little headroom in our engine room, we have always had considerable trouble in getting it down and back in place, due to this unbalancing, as the casting weighs probably 1000 lb. or over.

It was finally decided to put a large eyebolt in the top of the elbow to facilitate handling, but the question was "Where shall we put the eyebolt to balance it perfectly?" After some deliberation the following method was used to locate the proper position for the eyebolt:

The elbow was lowered to the floor and a piece of iron pipe as shown at A placed underneath it. It was then rolled back and forth on this pipe until a perfect balance was obtained, and blocked in this position. The distance B from the center of the pipe to the outer edge



SKETCH ILLUSTRATING METHOD OF LOCATING EYEBOLT

of the bottom flange was taken. A plumb line C was dropped to the edge of the flange and the distance B transferred to B^1 from the plumb line to a point D on the elbow. This locates the point D directly over the center of the pipe A. The hole for the eyebolt was then drilled about 1½ in. higher up on the elbow at E on account of the angle at which the eyebolt enters the casting. This brings the highest point in the eyebolt directly over the center of the pipe A.

A large washer and nut on the inside of the casting completed the job. A few strands of packing wound under the washer makes an air-tight job of it and the eyebolt is left in this position, always ready for use.

When we raised the elbow it hung perfectly plumb and was swung into position in a few minutes without any trouble and without damaging the gaskets. This will save us about an hour's time every time we take the elbow down or replace it and is much safer.

M. L.

Peculiar Case of Vibration Stopped Accidentally

IN THE PLANT under the writer's charge, there are two 72-in. by 18-ft. horizontal return tubular boilers, both overhead suspension. When I first became acquainted with the place, these boilers supplied steam for an old 18 by 48-in. Corliss engine that turned 72 r.p.m. No trouble was ever experienced with vibration in any form as long as this engine was in commission,

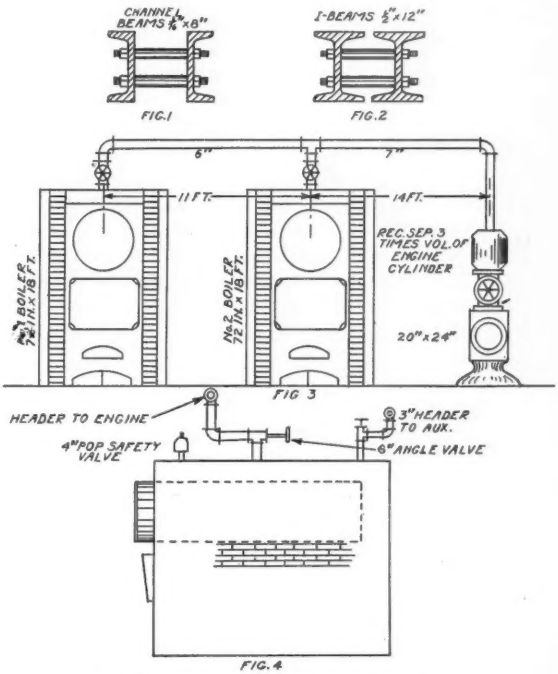


FIG. 1. SECTION OF CHANNEL BEAMS
FIG. 2. THE NEW SUSPENSION BEAMS
FIG. 3. FRONT VIEW OF INSTALLATION SHOWING HEADER ARRANGEMENT
FIG. 4. CONNECTION TO HEADER

but on account of changes and additions of new buildings it became impossible to drive much of the machinery with the old engine which was all but a wreck. It was, therefore, not advisable to try to run a belted generator with it so finally the engine was shut down, central station service installed and everything motorized, the boilers being used for heating purposes only. That was about the time I got charge of the job

(I had been firing it for 5 yr.) It took me 5 yr. to get what I was after, but finally I got a new high-speed Corliss engine, direct connected to a 250-kw. generator. Everything started off O. K., but after running about 3 mo. No. 2 boiler developed a case of vibration and the longer we ran the worse it got. One could sit in the superintendent's office 100 ft. from the boilers and feel the vibration and see the window shades tremble. Several engineers, both operating and consulting, were called in and each one proposed a different remedy.

At last a boilermaker of wide experience was called in and he recommended new suspension beams. The old suspension beams were made up of channel beams 3/16 by 8 in., made up in pairs as shown in Fig. 1 with a span of 11 ft. Before they were changed, the vibration was so bad that it nearly knocked down the outside wall on No. 2 boiler and braces were put in between boiler setting and engine room wall to keep the setting up. The middle buckstay broke off even with top of brick work from the strain. The vibration was not present all the time nor was it always up and down. In fact, as one man said, "the boiler bounced." When it would start the boiler would move up and down at the rate of 400 moves per minute or a bounce to each cutoff of the engine. The new suspension beams were made up of ½ by 12-in. I beams, in pairs, and after they were put in the trouble disappeared for about two weeks and then showed up again, not quite as violent as it was originally, but still too violent for comfort of mind, as every once in a while something would let loose. We never had a serious accident, however.

Things finally got to such a point that bids were called for on a layout of a new header. While the plans were being drawn I decided to repair the covering on top of the boilers and stripped all the old covering off, adding enough new material to cover the shells 3 in. thick with 80 per cent magnesia cement and a layer of brick on top of that, laid flat, making a total of 6 in. altogether. The engine has been run 4 mo. since this new overcoat was put on and there has been no trace of any vibration or bounce whatever.

At the worst of this boiler's performance the motion seemed to assume a rotary direction, bouncing up and down and swinging from side to side at the same time. After the application of the 3 in. of plastic covering and one layer of brick, what became of the disturbance? Altogether about 15 men were called in consultation and one and all were agreed that it surpassed anything they had ever been up against and some of them were men whose experience embraced almost every kind of steam generating apparatus used at present on land or sea. Discussion on this subject by the readers will be appreciated.

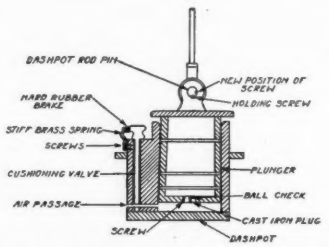
OPERATOR.

Curing Dashpot Troubles

IN A TYPE of Corliss engine having dashpots such as shown in the accompanying sketch, the cushioning valve consists of a straight steel pin, having a 3/16-in. hole drilled through it near the bottom end, corresponding with the air-passage from the bottom of the pot. The cushioning is accomplished by turning the pin to get the desired opening. When new, the pin is a close fit and will "stay put" but it was found that after long service it would become loose, and a slight jar would shift the pin, allowing the plunger to slam on the bottom of the pot or hang up. In our case we made a brake. A piece of heavy spring brass was bent to shape and secured to the casting with two ¼-in. screws a short piece of thick rubber, cut from an old pump-valve was riveted to the top end of the spring and fitted to handle of the pin. This acts as a brake and holds the pin securely in any position in which it may be placed.

In this type of dashpot a cast-iron plug, containing a ball check, is screwed into the bottom of the plunger. These plugs sometimes become loose and unscrew so that they may strike the bottom of the pot. We drilled and tapped a ⅜-in. hole lengthwise through the thread of the plug and put in a close-fitting machine screw, with a flush head, which cured that trouble.

No provision is made on this engine for taking up lost motion on the lower pin of the dashpot rod. The bearing is a solid brass casting, and the pin is held in position by a setscrew in a hole tapped lengthwise of the pin, one-half of the hole being in the pin, and half



SECTION OF DASHPOT SHOWING METHOD OF REMEDYING TROUBLE

in one of the lugs on the plunger. The wear being only on the top and bottom of the pin, I have found that turning the pin a quarter turn and tapping a new hole for the setscrew often helps to make the engine run more quietly.

Care should be taken to keep an accumulation of oil from the plunger. A quantity of dirty oil in the plunger is liable to gum up the opening, or cause the ball check to stick and make trouble at a time when the engineer cannot get at it to make the correction.

M. M. BROWN.

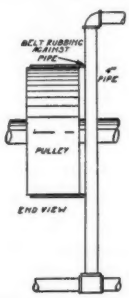
Sand Prevents Belt Slipping; Carelessness Ruins Belt

THE BELT on a high-speed steam engine driving a line shaft in the factory was badly soaked with oil due to the fact that the main engine bearing next to the belt pulley leaked oil badly and threw it into the belt pulley whence it found its way to the belt. Whenever the belt slipped, powdered rosin was thrown on it which prevented it from slipping for a short time, when more rosin was thrown on the belt. One day the belt slipped badly again, and to make matters worse there was no rosin on hand. One of the factory employes standing near and noticing a box with fine sand in it, suggested to throw some of this sand on the belt. This was done, a handful of the sand thrown on the belt and, you may believe it or not, but the belt took hold of the load immediately and has not slipped for about two months.

The reason the sand stopped the belt from slipping was due, I believe, to the fact that the sand soaked up

some of the oil in the belt, also roughening the surface of the belt. To say the least, this treatment of a belt is very injurious and should not be allowed. It not only is injurious to the belt but there also is the danger when throwing the sand on the belt of getting some of it into the engine bearings, cutting them and causing a hot bearing. In a case of this kind the engine bearing that leaked oil should have been repaired or put in a condition so it would not leak long before the belt had been soaked with oil and whatever oil there was in the belt at that time could have been easily removed by washing it with gasoline or by heating and scraping.

Just to show what carelessness at times exists in some plants, I relate the following: In a certain manufacturing plant it was necessary to run a 4-in. hot water pipe in a vertical position. In doing this it was necessary to run this pipe within an inch of a pulley and belt as shown in the illustration. Whenever a heavy load was suddenly thrown on the belt, this would run



BELT RUBBING AGAINST PIPE

off the pulley for a second to the side on which the pipe was located so that the edge of the belt would rub against the belt, wearing off part of the belt edge in a short time. Nobody paid any attention to this until one day it was heard that there was something loose on the belt which was striking some object near the belt. After shutting down and examining the belt, it was found that the edge of the belt running next to the vertical pipe had worn to such an extent that some of the belt lacing holes were worn through next to the belt edge, allowing the belt lacing to fall out. A temporary repair was made on the belt, but before starting up again the cause of the trouble was removed by shifting the pulley farther away from the pipe. The pulley should have been shifted as soon as it was noticed that the edge of the belt was rubbing against the pipe, as there was nothing to interfere with moving both the driven and driving pulley; or the belt could have been placed in a condition to prevent slipping either by shortening it sufficiently or by applying a belt dressing.

H. A. JAHNKE.

Fighting Scale

THE BEST method of preventing scale formation in boilers is to remove scale forming material from the water before it enters the boiler. The equipment for doing this efficiently is somewhat costly, but even at that it usually turns out as a profitable investment. As long as the belief exists, however, that feed water can be successfully treated after it enters the boiler, just so long will chemical mixtures of an unknown composition be used by some engineers in an endeavor to prevent the formation of, and to remove scale. At the present date, compounds are being pumped into thousands of steam boilers, and in many cases the users do not know what ingredients or chemicals are in the compounds.

Dangerous chances are taken when compounds are bought from unknown makers. When a compound is bought, the dealer should be a responsible concern and even at that compelled to give a "cast iron" guarantee that the compound is harmless to the boiler iron no matter in what way or what quantities it is used.

We all know that tannic acid will remove scale; we also know it will remove iron along with the scale; yet what proof have we that some "cure-all" compound does not contain some of this dangerous acid? Such a compound may contain dextrine and gum, both of which are dangerous, as they will coat the interior of the boiler with a waterproof covering. Many individuals condemn homemade compounds. Whatever bad features such homemade mixtures may possess, they have one important advantage in their favor—the user knows what chemicals he is pumping into the boilers. While the high cost of some chemicals prohibits their use as compounds, there are two materials which are low in cost and have proved more or less effective in loosening up scale and will not injure the boiler when used intelligently. These are caustic soda and soda ash. Crystallization of the boiler iron has been charged against caustic soda; but as far as the writer knows, no proof has been forthcoming to bear out the charge.

Many compounds are for sale at a cost of $40 to $80 a barrel. To learn whether such compounds contain harmful chemicals, it will pay the user, if permissible by law, to have an analysis made, even if the cost is $25 or more. You may also be surprised to learn that some inexpensive homemade article you are using is much better, perhaps not costing over $5 or $10 a barrel.

JAMES E. NOBLE.

Another Engine Breakdown

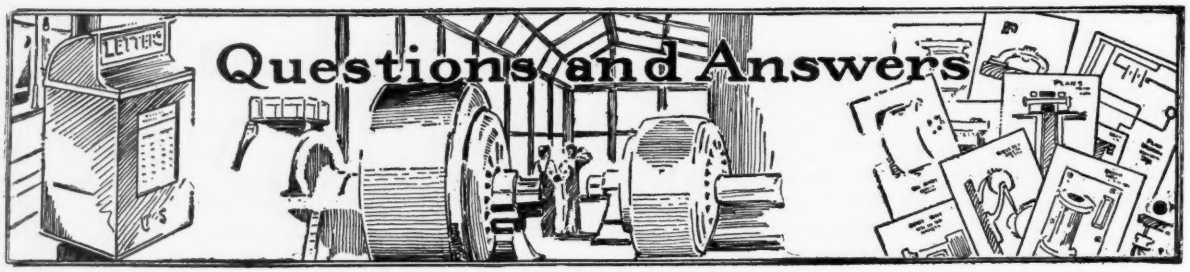
READING the letter by Joseph English in the Feb. 1 issue, "Engine Breakdown," I am reminded of a similar incident which occurred at a small plant where my brother once worked. He did not work in the engine room, but was nearby when the accident happened.

The engineer kept his boiler too full constantly. Two or three days before the accident I spoke to him about it, and he replied: "Yes, I know it's too full. I ran so much water through her this morning that I nearly pounded off my blamed cylinder head."

A few days later the priming became so extensive that it broke the piston rod between the piston and the crosshead. The engine was a rather small one, and the piston comparatively light, but the head was cracked across in several places, and a hole burst in the middle. The engineer shut off the steam about 10 sec. after the piston rod broke, but the damage was done.

The piston rod was welded, and the new head obtained from the makers, the plant being shut down about four or five days. The next time I visited the plant, the boiler was still too full, priming badly. Why cannot some punishment be provided for such carelessness?

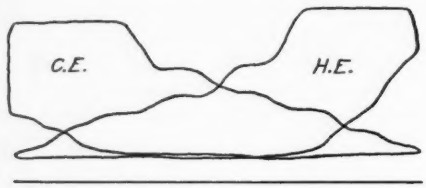
GEO. F. SWETNAM.



What Remedy Would You Suggest

WHAT IS your opinion as to the cause of the irregularities in these two indicator diagrams, and what remedy would you suggest? The first card was taken from the high pressure side of a four-valve angle compound engine, size 12 by 20 by 11 in., running at 300 r.p.m. The valve mechanism is the indirect type; the cutoff is automatic and is governed by a shaft inertia governor. The engine is fed through a 4-in. line with steam at 120 lb. gage.

The engine showed a good card before the high pressure piston was refitted to the cylinder. The present



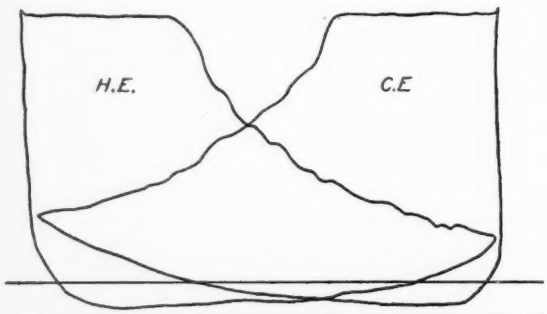


FIG. 1. INDICATOR DIAGRAM FROM HIGH PRESSURE SIDE OF COMPOUND ENGINE

FIG. 2. CARD FROM CORLISS TYPE ENGINE

card was taken after the refitting, though no change was made in the valve mechanism.

The second card was taken from a releasing gear Corliss, size, 18 by 42 in.; 100 r.p.m.; steam pressure, 100 lb. gage; vacuum, 25 in. E. P. C. and W. J. M.

What Caused This Pump Failure?

WE HAVE at our plant four 2000-hp. outside packed plunger feed water pumps supplying 20 horizontal water-tube boilers, 500 hp. each. For the past two weeks these pumps have been breaking studs and glands and cracking the cylinders around the studs. I can find no possible explanation of this behavior and so would like the opinion of Power Plant Engineering readers as to the cause of and possible remedy for this situation. A. H. F.

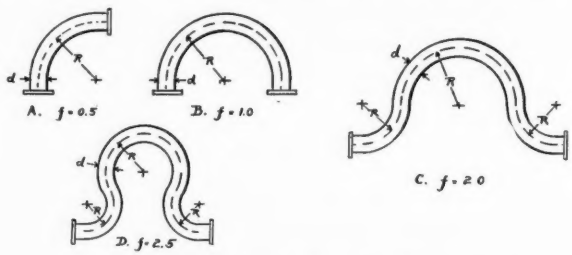
Lubricator Refuses to Function

THERE IS under my charge a 1000-gal. per min. steam pump, the lubricator on which acts for a few minutes after starting and then stops feeding. I was about to throw it away when I decided to install it on another smaller pump and put the second lubricator on the first pump. After the change the lubricator on the first pump ceased to function as before although the first lubricator worked well on the small pump. Neither will work on the large pump, but both function on the smaller one. What is the reason for this action?

M. C. K.

Stresses in Pipe Bends

REFERRING TO C. C.'s inquiry in the Feb. 15 issue regarding stresses in pipe bends, the maximum stress in the pipe would be comparatively easy to figure if it were known just what the resistance of the anchors or supports holding the pipe is: but this is usually indeterminate, and the only measure of the stress is the motion of the ends of the expansion bend taking up the increased



FORMS OF EXPANSION BENDS

or decreased length of the pipe line. The force which could be generated by the expansion of the pipe is not a true measure of the stress as the actual stress in the line after expansion is only that by which the resistance of the supports, etc., prevent this expansion from being complete. For instance, steel having a coefficient of expansion of 0.000,006,5 per degree Fahrenheit would exert a force of 30,000,000 × 100 × 0.000,006,5 = 19,500 lb. per sq. in. if heated 160 deg. F. and absolutely prevented from expanding and would itself be under this stress, but if allowed to expand freely, would exert no force and be under no stress.

The relation of the compression of pipe bends or other curved pieces to the greatest stress in the material is a very complicated one and involves a great deal of the higher mathematics. Anyone who wishes to go into it can find it in Bach's Elasticitat and Festigkeit (no known English translation) Section 54, or, for a simple U bend the formula for circular links in Bulletin 18,

The Strength of Chain Links, of the Engineering Experiment Station of the University of Illinois applies.

For practical purposes Crane Co. carried out a very elaborate series of tests a few years ago and very generously published the results widely. They found that the safe amount of expansion which could be taken up by a bend without damage to itself or the adjacent piping was given by the formula:

$$E = f \times \frac{0.0052\,R^2}{d}$$

where E = expansion to be taken care of, in inches
R = radius of center line of pipe in bend, in inches
d = outside diameter of pipe in inches
f = a factor depending on the form of bend being 0.5 for a quarter turn bend as shown at (A) in the accompanying illustration, 1.0 for a U bend (B), 2.0 for an open bend (C), and 2.5 for the double bend (D).

This formula applies to standard weight pipe such as is usually used for Cranelap and Van Stone joints, for thicker walled pipe the allowable expansion is inversely proportional to the thickness.

For instance, for a 6-in. line, using a bend of the type shown at D, with a 60-in. radius in the bends, the allowable expansion would be:

$$E = 2.5 \times \frac{0.0052 \times 60 \times 60}{6.625} = 7.05 \text{ in.}$$

and if for any reason it were desired to use extra heavy pipe this would be reduced in the proportion of

$$7.05 \times \frac{.280}{.438} = 4.50 \text{ in.}$$

Either of these is rather more expansion than is desirable to accumulate in one place so the radius could be reduced to about 40 in., giving

$$E = 2.5 \times \frac{.0052 \times 40 \times 40}{6.625} = 3.13 \text{ in.}$$

In most piping layouts where the designer is not hampered by existing conditions it is possible to arrange the piping so that expansion is cared for without the deliberate introduction of expansion bends. If these must be used, every effort should be made to keep them in a horizontal plane, as otherwise the line is protected and one more possible source of trouble introduced in case of accident to traps.

H. D. Fisher.

Operating Suggestions for Refrigerating Plants

We have a double-pipe ammonia condenser, the water pipe of which is badly scaled. What is the best method of cleaning them? How would it do to fill them with kerosene for a few days? Would it loosen the scale?

2. Where is the proper place to connect a regenerator, bottom of receiving tanks, bottom of oil traps, or bottom header of refrigerating coils (flooded ice system)?

3. Can I use my steam engine indicator on my ammonia cylinder without injury? I have been told that I could if I would dip it in vinegar and then in oil after using.

4. Is it advisable to lift main engine shafts and cut oil grooves if the shaft is running warm? We use a grease gun to lubricate the bearings.

5. Is there any way to prevent moss and scum fouling our screens in our cooling towers? (b) Our cooling water enters cooling tower at 130 deg. F. and leaves at 85 deg. atmosphere 90 deg. Is that as good as could be expected, with a plain open tower and no fans?

6. Is there any economy in using a high boiler pressure when 100 lb. does the work? E. N. G.

Answers

The method to be most advantageously employed in cleaning the water pipes of double-pipe ammonia condensers depends so much on the physical condition and chemical composition of the scale that it is impossible to give more than general suggestions.

You might try some of the mechanical cleaning tools on the market which are similar to those used for cleaning scale out of boiler tubes.

If the scale is so hard that it cannot be removed by running a hand-scaling tool through the tubes, it is doubtful whether the method you suggest would do any material good insofar as removal of the present deposit is concerned. The virtue of oils is to produce a non-homogeneous "rotten" scale formation rather than to affect the scale after it is formed. For this purpose a heavier oil is more advantageous because it leaves a heavier deposit tending to produce a line of cleavage between the layers of scale deposited before and after the oil application. This process may be best illustrated by describing the old method employed in locomotive practice in the so-called "hard water" districts.

The boilers are blown immediately on entering the roundhouse or as soon as the pressure will permit, the wash-out plugs are removed and cold water under high pressure is immediately directed over the hot tubes and sheets. This causes much of the hard scale to crack off of the outside of the several surfaces because of its contraction in contact with the cold water while the metallic surfaces beneath are still hot. The cracking occurs naturally along the lines of least resistance which are the strata where oil has been deposited in previous treatments.

After thoroughly washing out, the plugs are put in and a quantity of crude oil is run into the boiler which is then filled with water. The oil floating on the surface of the water as it rises through the tubes coats them so that scale subsequently formed will not be an uninterrupted continuation of the crystalline mass of scale already formed, but will be separated by thin layers of oil-soaked scale which form the lines of cleavage.

It will be noted that this method, which is not 100 per cent effective, is more effective as applied to scale on the outside of boiler tubes than it would be to that on the inside of condenser tubes. It is possible, however, that the method suggested may not be without merit for use on condensers.

If turning off the cooling water until the water pipe and scale has come to the temperature of the condenser and then suddenly turning on the water seems to have any loosening effect after the formation of a considerable coating of scale, it would undoubtedly prove of benefit in the prevention of a considerable thickness of scale

if practiced daily when the scale is in the process of formation.

Swabbing out with crude oil or oil and graphite would undoubtedly tend to make the scale more readily removable.

If the tubes have to be removed, some such operation as drying, rattling, hammering and scraping, preferably after heating, may be found sufficiently effective to warrant its use.

2. Connect your regenerator with valve to all of the parts you mention and any others where oil may trap. Discharge into regenerator one at a time.

3. You can use a brass steam indicator for ammonia work, provided it is used with discretion. It is advisable to dip the parts in "ice machine" oil *before* employing the indicator for ammonia work. Even then the indicator should not be allowed to remain in contact with the ammonia any longer than is necessary to perform the task, and should be immediately taken apart and thoroughly cleaned. Do not dip the parts in vinegar, first, because there is no occasion for it as the free ammonia will readily leave the metal by diffusion into the air during the cleaning process and the ammonia in solution in the oil will be removed with the oil, and, second, because neutralizing an alkali, such as ammonia, with an acid such as vinegar (impure acetic acid) forms a salt, such as ammonium acetate, which might prove detrimental, by promoting other chemical reactions with the constituent metals entering into the alloy of which the indicator is made. While it cannot be definitely stated that such reactions will take place, the chances are greater the more chemical elements are present, all of which must be in equilibrium in order that there shall be no tendency toward change. The safest way is to clean thoroughly and dry the apparatus at a moderately high temperature, then carefully oil it before putting it away.

4. A warm main engine shaft may result from so many and varied causes that a "yes" or "no" answer would be of little value. If there is sufficient reason to think that the heating is due to poor oil distribution the cutting of the grooves might be warranted. Before taking this laborious step, however (it is assumed that the engine in question is for driving compressors used in the 85-ton ice plant and accordingly of fairly good size) it would be well to make sure that the heating is not due to improper keying up, poor alinement or some other cause.

5. We know of no practical way for preventing the growth of "moss" on cooling tower screens while operating under conditions so favorable to plant life. When the tower is not in operation the experiment of making up a strong salt solution in the condenser pan and circulating it over the tower might be tried.

The most effective way to destroy water plants such as moss and algae, which latter is probably the kind of plant life which composes the "scum" you mention, is to deprive it temporarily of water. This you will probably not find practical because of the impossibility of shutting down the tower long enough to dry it out thoroughly, without shutting down the entire plant.

(b) Without knowing whether or not you enjoy favorable atmospheric conditions, or, in other words, low relative humidity, we would be inclined to venture an opinion that a final temperature of 5 deg. below that of the atmosphere is good for a tower without fans. The performance of cooling towers is a rather complicated and involved subject and one can do little more than guess at results without full knowledge of all the numerous conditions which enter into the consideration, such as relative humidity, wind velocity, amount of water circulated, range through which it is cooled, construction and effective area of the wet surfaces, etc.

6. Unless you are "wasting" steam, which it is assumed you are not, since the plant is assumed to be of the distilled water type, there would be no increased economy in the use of a higher steam pressure. The prime function of the boiler plant where distilled water ice is made is to evaporate the water needed for the manufacture of ice. If no power were required the water would be evaporated at a low pressure and the steam would be conducted directly to the condensers. Since, however, power is required to drive the compressors of compression plants, the steam is evaporated at a sufficiently high pressure to permit of its operating a steam engine enroute to the steam condenser.

F. E. MATTHEWS.

What Vacuum Should Be Carried?

WILL A cross compound engine operate more economically at 23 in. vacuum than at 27 or 28 in.? If so, what are the reasons? About how much saving could be made on a 400-hp. engine?

J. E. K.

A. The increase in horsepower effected by the use of a condenser theoretically should increase in direct proportion to the vacuum obtainable. This, however, is not the case.

The mean effective pressure does actually increase approximately as the vacuum up to about 10 in. of mercury. At higher vacuums, the increase becomes less and less marked, until at about 26 in., the actual m.e.p. reaches an apparent maximum. These figures are not applicable to all engines, but give a good idea of the limitation of the economical vacuum for the average type of reciprocating engine with restricted exhaust port openings. With specially designed ports and passages of a large cross-sectional area, the piston engine may show an increase in steam economy up to the highest vacuum that can be carried in a condenser.

Another point that must be taken into consideration is the fact that the reduction in steam consumption, due to the condenser does not necessarily indicate a corresponding reduction of heat consumption. As an example, we take an engine cited by Professor Gebhardt in his "Steam Power Plant Engineering" which shows an apparent gain in steam consumption due to condensing of 12.5 per cent with a 28-in. vacuum, the temperature of the feed water returned to the boiler being 120 deg. F. With a suitable heater, the exhaust of the non-condensing engine would be capable of heating the feed water to 210 deg.

The non-condensing engine would therefore be credited with $210 - 120 = 90$ heat units per pound of steam used or about 9 per cent. The difference between 12.5 per cent and 9 per cent or 3.5 per cent, represents the net gain in favor of the condensing engine, provided that the power required to operate the condenser pumps is ignored.

Actually the steam consumption of the condenser pumps may be greater than the gain in economy of the main unit. The net gain would then become negative. The efficiency of the engine just mentioned, based on the water consumption, increases as the vacuum increases, reaching a maximum at about 27 in., whereas the heat unit curve shows a maximum at about 20 or 21 in. No rule can be laid down as to what vacuum can be most economically carried, each case will have to be worked out by itself on its own merits. In order to carry high vacuums, it is necessary that large pumps, large condensers and a large amount of water and more auxiliary power be used, all of which may cost more than the saving effected over using a lower vacuum. For this reason every plant will, in general, carry a different back pressure to obtain the best economy.

The point is to strike the most economical heat balance possible for the whole plant. It is of no avail, of course, to increase the economy and efficiency of any one unit of the plant, if, by so doing, the economy of another unit is lowered an equal or greater amount. You will see, then, that it would be impossible to say just what saving you might be able to make on the 400-hp. engine which you mention by operating at 23 in. instead of 28 in. of vacuum.

Synchronizing Generating Equipment

I OPERATE a hydroelectric power plant which for about 100 days of the year is overloaded 3 to 4 hr. every day. The generators are belt driven from a horizontal line-shaft and would supply the current if I had sufficient power behind them.

I have a 25-hp. steam-engine and boiler and a spare 52-kw. generator set. Which is the best way to obtain my additional power?

A. By belting the steam-engine to the turbine line-shaft?

B. By driving my spare generator set with steam-engine, and synchronizing the two plants?

Both generators are 2300-v., 60-cycle, 7200-amp. single phase. One runs at the speed of 720 r. p. m., the other at 900 r. p. m.

If practicable, it would be a simpler installation to connect the steam-engine to the turbine-lineshaft and do away with the nuisance of operating the two generator sets.

E. L. S.

Finding the Indicated Horsepower of an Engine

WILL YOU kindly explain the method of finding the indicated horsepower of a steam engine, when the mean effective pressure is not known? The engine in question is a cross compound blowing engine, size 16 by 48 by 48 in., operating under a throttle pressure of 200 lb. gage, a receiver pressure of 15 lb. gage and a back pressure of 23 in. mercury; maximum speed, 70 r.p.m.

2. What would be the most economical receiver pressure to carry? C. O. S.

ANSWERS

IN ORDER to be able to determine the indicated horsepower of an engine, we make use of the equation HP. = PLAN ÷ 33,000, where P is the mean effective pressure, L is the length of stroke in feet, A is the area of the piston in sq. in. and N is the strokes per min. Obviously P will have to be found before the equation can be solved. For this purpose we will assume a perfect square in which the expression follows Mariotte's law, i.e., pressure varies inversely as the volume, and in which the terminal pressure equals the back pressure, a condition which does not ordinarily hold for an actual engine. If the terminal pressure is above the back pressure, the power will be greater than that found by the following method.

For an initial pressure of 215 lb. per sq. in. absolute and a back pressure (considering now only the high pressure cylinder where the back pressure is the receiver pressure) of 30 lb. abs., in which case the ratio of the terminal to initial pressure is $30 \div 215 = 0.1395$, we find from a table given in Kent on page 960 that the cutoff is about 14 per cent of the stroke and that the ratio of mean to initial pressure is about 0.42. The actual m.e.p. is then $0.42 \times 215 = 90.5$ lb. Substituting this with the other known values in the equation

$$HP = PLAN \div 33{,}000$$

we find

$$HP = 90.5 \times 4 \times 0.7854 \times 16^2 \times 2 \times 70 \div 33{,}000$$

$$HP = 308$$

The ratio of expansion in the low pressure cylinder is, of course, the ratio of the cylinder volumes, i.e., 48^2 to $16^2 = 9$ to 1. With this ratio we find from the same table that the ratio of the mean to initial pressure (in this case receiver pressure) is 0.355, hence the actual mean effective pressure is $0.355 \times 30 = 10.65$ lb. The horsepower developed is then

$$HP = 10.65 \times 4 \times 0.7854 \times 48^2 \times 2 \times 70 \div 33{,}000$$

$$HP = 328$$

The total for both cylinders is then $308 + 328 = 636$ hp.

2. The most economical receiver pressure is that which will give equal indicated horsepower in both cylinders. The receiver pressure which should be used to obtain this result may be found from an equation given in Ninde's "Design and Construction of Heat Engines."

$$Pm = Pi \div \sqrt{Pi \div Pb} \times \sqrt[3]{(\sqrt{Pi \div Pb} \div \sqrt{Pi \div Pk})}$$

in which Pi is the initial pressure, Pm the receiver pressure, Pb the back pressure, and Pk an empirical pressure which may be taken at from 3 to 6. We will assume Pk = 4.5. Pb is the absolute pressure in lb. per sq. in. corresponding to 23 in. vacuum, which amounts to about 3.5 lb.

Solving this equation, we find

$$Pm = 215 \div \sqrt{215 \div 3.5} \times \sqrt[3]{(\sqrt{215 \div 3.5} \div \sqrt{215 \div 4.5})} = 215 \div 785 \times \sqrt[3]{(785 \div 6.91)}$$

$$= 28.6 \text{ lb. per sq. in. abs.}$$

which corresponds to about 14 lb. gage, which closely approximates the pressure you are carrying.

To Drill Small Metal Pieces

HE WAS one of the young men from the office. Stepping into the shop, he essayed to drill a small piece of metal, but was unable to grip it. The old fellow in overalls, grinning, handed him a piece of rough emery paper, saying: "Lay it on here and go to it." The job was finished in a jiffy, the young man passing him a cigar. J. B. DILLON.

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The Engineer as a Specialist

In this age of specialization when progress in practically all fields of human endeavor has attained high and complex stages of development, when the only man whose services are in demand is the specialist whose entire experience and efforts have been directed towards mastering the multitudinous details and ramifications of his particular profession, the operating engineer in the power plant may often have cause to wonder about his own status in the general classification of things. Is the operating engineer a specialist?

Offhand we might say, yes, he is a specialist in operating practice. The latter, however, is so broad a term and its very use in this connection so neutralizes the meaning which the word specialist conveys, that we hesitate to use it. The dictionary defines the word specialist, as "one who devotes himself to some specialty."

The average operating engineer is in charge of some four or five classes of equipment each in itself sufficiently complex to require the attention of a specialist. His work, as a consequence, is extremely diversified. One day he may be called upon to direct the repair of a boiler; the next day the refrigerating system may demand his attention; again, it may be that something has gone wrong with the electrical apparatus. In each case the operating engineer must be able to diagnose the trouble and, if possible, to re-establish proper operation. A hundred times in the course of his day's work new problems arise, the solving of which often taxes his ingenuity to the utmost.

Just as the country practitioner in the medical profession deals with the ailments of the human body as a whole, so does the operating engineer deal with the power plant as a whole. Similarly, in the same manner that certain doctors specialize in diseases of a particular part of the body, so do certain engineers specialize in a particular branch of engineering. In the design of electrical machinery, for example, a man specializes in generators. Not only are his entire efforts limited to the design of generators, but perhaps, only to a particular class of generators, say high speed alternating current generators. Another man devotes himself only to direct current generators. Both are electrical engineers, yet neither knows a great deal of the other's line of work. In probably no other branch of engineering has specialization been confined to such narrow limits as in the design of machinery.

The operating engineer, while thoroughly conversant with all details of operation could not be called a specialist of each class of equipment under his charge. It is not to be expected that his knowledge of condensers, for instance, is equal to that of the man who has devoted his entire engineering experience to a study of condensing equipment.

What the power plant engineer probably does know, better than anyone else, is the operation of each machine in relation to the plant as a whole. To him the entire plant is a machine of which the individual pieces of apparatus are merely parts. His duty is to effect proper coordination and to maintain an harmonious adjustment between the various machines which constitute the plant. He should possess an intimate knowledge of the relation which his plant bears to the industry it serves.

The engineer of the power plant then, must possess a broad knowledge of everything which relates to his plant. It is the plant he is concerned with, and he is less interested in the efficiency of any one machine than he is in the overall efficiency of the plant. To that end he must apply his efforts, and it is only by so doing that he can earn for himself the title of specialist in operation.

Power a Byproduct

Conservation of fuel has been the aim of practically every improvement in design of power plant equipment and management since the increase in coal prices during the war. Engineers have investigated the economy of every conceivable means for reducing fuel consumption; the United States Government was persuaded to appropriate $125,000 to make the Superpower Survey with the sole object of finding and recommending ways of conserving fuel used for power purposes. Little attention, however, has apparently been given to a co-operative agreement between central stations and privately owned power plants whereby purchased power could be used at times when it proved more economical than that generated in the private plant.

It has long been known to engineers that in the generation of power only a small percentage of the heat in the steam is available, the remainder must either be lost in the condenser or the atmosphere, or may be utilized for some heating purpose. There is, of course, considerable contention in regard to the size of a power and heating plant that can compete economically with power purchased from a utility and so far only general statements have been made, such as the following quoted from the report of the Superpower Survey.

"In general it has been found that industrial establishments which require 500 hp. or less can economically purchase energy. Only those that need more than 500 hp. and have special requirements for heat can generate their own power economically, and even these should have central station connections to take up irregularities of load."

Recognizing that steam exhausted to atmosphere for a portion of the year, even, is an economic waste many isolated power plants having no use for heat during the summer have arrangements for closing down their plants during these months and purchasing power. In many instances, this practice has resulted in economy to the plant while in others advantageous arrangements could not be made with the utilities and the former custom of continuous operation was reverted to.

At the present time, the well informed engineer who has kept adequate records can calculate to a fair degree of accuracy what the plant could afford to pay for power and when it is more economical to generate its own power. In other words, the problem is now one of business rather than engineering.

Now comes the arrangement employed by the Franklin Manufacturing Co., whose plant is described on other pages of this issue, whereby the company generates only enough power to supply the factory with the exhaust steam needed and purchases the additional power required from the utility company. Power generated in the plant is thus secured purely as a by-product, the turbines acting as reducing valves to supply only the amount of steam required. No waste of steam either to condenser or atmosphere is permitted. Such a scheme would appear to be ideal from an engineering standpoint and the results obtained in this plant will be watched with interest by engineers throughout the country.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Where to Take Hold*

By Dr. Frank Crane

THE PLACE to take hold is Here.
Right Here.
And the time to begin is Now.
Right Now.

If you don't know how to go at it right, go at it wrong, but go at it.

All the worth-while things of this life are difficult. Nothing's easy but slumping.

Most of the problems that affect your happiness are complicated.

And the way to perform a difficult and complicated task is to go to it somehow.

For you learn by trying.

Life is an art, not a science. It is mastered by experiment, and patience, and infinite beginnings again. Nobody in the world can learn just what to do before he does it; I mean in the way of living and getting along with associates.

If your desk is cluttered with a dozen half-finished matters, clean it up now. Decide. Act.

If you owe money, pay it. If you cannot pay it, make the best arrangements you can with your creditor now. Don't evade and equivocate. Don't dawdle.

If you have a bad habit that is throttling you, take hold now. You must conquer it some time, and every day you delay your fight your enemy grows stronger.

If you want to save money and get a little ahead, put a portion of what you have now in the savings-bank. Nothing is finished that was never begun.

If you really want to be charitable and help your fellowman, give of what you now possess.

If you are not helpful with only a dollar in your pocket, you would not be if you had a million.

Do it now.

What you are going to do some day may be a sickly dream. It's what you do today that means something.

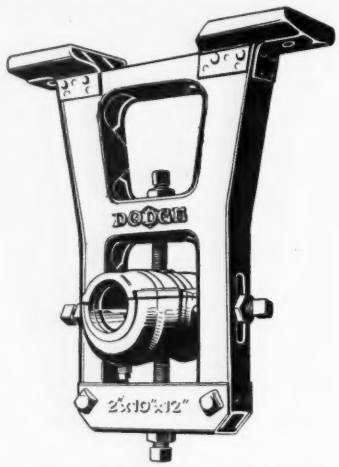
The only theory that is of any value is the one that gets into your fingers right now.

The place to take hold is Here!

*Copyright, 1922, by Dr. Frank Crane.

Light Line Shaft Hanger

TO MEET the demand for a light hanger for line shaft support, the Dodge Sales and Engineering Co. has brought out and is offering to power users a pressed steel hanger. This hanger is designed for general purpose work where extreme vibration is not



PRESSED STEEL SHAFT HANGER

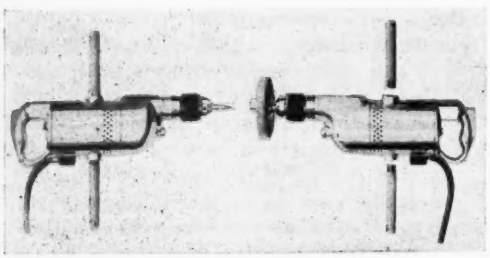
a factor, or where the service is not severe or unusual and where first cost is of prime importance.

The hanger is of extremely light box section construction, the various members making up the frame being riveted and bolted together as shown in the accompanying illustration.

New Combination Drill and Grinder

A NEW combination portable electric drill and grinder has recently been placed upon the market by the Wodack Electric Tool Corporation. The accompanying photograph illustrates this tool, when used as a portable electric drill and also when used as a portable electric grinder.

This new tool will be of value in shops and factories where hand drilling and grinding operations are performed, yet not enough of either to warrant the



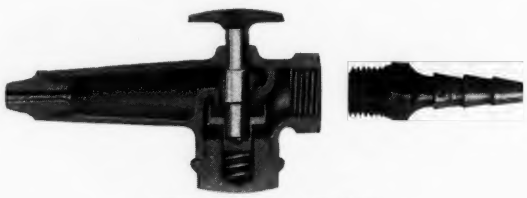
TOOL USED AS BOTH DRILL AND GRINDER

purchase of two separate machines. In designing this tool, it was necessary so to construct it that by the use of one motor it would have the desirable speed for drilling, as well as the proper speed for grinding.

This combination tool can be used for drilling holes in metal or wood, and when used with grinding wheel attachment will cover the average requirements for grinding. It has a drilling capacity of ⅛ in. to ⅝ in. in steel, and when used as a grinder carries a 6 by ¾-in. grinding wheel. Two separate speeds are provided, the slow speed for drilling and the high speed for grinding. The complete weight of the tool is but 18 lb., while the motor develops ½ hp. under load. The switch is located in the top handle and is of the quick-make-and-break automatic-stop type, which insures the operator of having the tool under control at all times. Aluminum castings and ball bearings are used throughout. The tool is very simple in construction, yet rugged enough to withstand the hard service to which a tool of this kind is frequently subjected. The motor is of the Universal type, consequently can be operated on both direct and alternating current of the same voltage. The speed change is a very simple operation, as is the operation of changing the grinding wheel attachment in place of drill bit or vice versa.

Saving Compressed Air

AIR, when compressed and converted into a form of transmitting energy, ceases to be "free"; machinery, equipment and labor enter into making it an item of cost; and the cost of compressed air is increased by any waste or leakage before the final application to the work to be done. Due to such leakage through joints and wastage at the tool or nozzle, the over-all efficiency of a compressed air system is often reduced 40 to 60 per cent.



JENKINS BROS. AIR GUN

Jenkins Bros. has recently perfected and is now marketing a brass air gun with renewable disc which is an innovation in equipment of this kind. The disc has perfect contact on the seat, takes up the wear of frequent usage and can be quickly renewed if necessary. This gun is finding wide use for general dusting in shops and everywhere that a blast of air is required for cleaning as in electric stations.

News Notes

GEORGE J. HAGAN, Pittsburgh, Pa., announces the opening of a branch office in Chicago, 20 E. Jackson Boulevard, under the management of V. A. Hain, formerly with the General Electric Co.

THE AMERICAN STEAM GAUGE & VALVE MFG. CO., Boston, Mass., announces the opening of a new branch office at Real Estate Trust Bldg., Philadelphia, Pa., in charge of L. E. Gebhardt, formerly district manager for Yarnall-Waring Co., of Philadelphia.

THE WILSON Welder & Metals Co., Inc., New York, N. Y., announces the appointment of R. L. White as

district manager in charge of Detroit office, 809 Kresge Building, Detroit, Mich.

THE HARDINGE CO. announces the acquirement of the coal washing equipment as formerly supplied by the Coal Washing Equipment Co., of Pottsville, Pa. The equipment consists mainly of the James Automatic Balanced Jig, a device which has been developed and installed in a number of anthracite and bituminous collieries for reducing the sulphur and non-combustible of coals ranging in sizes from ¼ to 4 in. Another device which has just shown surprisingly good results is a combination of pulsating classifier and table which is capable of lowering the sulphur and ash content of slack sizes of coals, and also the washing of river coals and anthracite culm. Noel Cunningham, formerly connected with the Coal Washing Equipment Co., has now become associated with the Hardinge Co. and has been placed in charge of this new department.

WHITING CORPORATION, of Harvey, Ill., has established a branch sales office in New York City at 136 Liberty St. J. Ross Bates, now a vice president of Whiting Corp., is in charge of the new office. He will be assisted in the New York territory by D. Polderman, Jr., and in the New England States by R. C. Maley, who will open an office at Springfield, Mass. Another branch office has been opened in Indianapolis, Ind., 305 Merchants Bank Bldg., in charge of S. E. Stout. The Detroit office has moved from Penobscot Bldg. to the Stahelin Bldg.

NEGOTIATIONS HAVE recently been consummated whereby R. W. Monger, of Elkhart, Ind., has purchased controlling interest in the Godfrey Conveyor Co.

At the last meeting of the board of directors, Mr. Monger was elected president of the company. Other officers elected were B. C. Godfrey, vice president; D. H. Herbster, treasurer, and Chas. E. Clouse, secretary. The board of directors includes all officers of the company together with James H. Channon, of Chicago, Ill., and Fred W. Reid.

At this meeting it was announced that the Godfrey Conveyor Co. would aim to serve a wider field in supplying additional equipment now perfected and ready for the market. This new equipment includes the Godfrey Standard Car Puller which is designed economically to serve all general car moving needs, and Godfrey Single Drum Hoists which are destined to fill a great need among contractors and manufacturing plants. The company states it is anticipating business which will closely approach "normal" during 1922.

Book Reviews

MASTERING POWER PRODUCTION, by Walter N. Polakov; size 6 by 9 in., 445 pages, 138 illustrations, cloth; New York, 1922.

Mastering Power Production is a clear and logical presentation of the engineering, managerial and economic fundamentals which underlie the now generally recognized necessity for industrial readjustment, and for better utilization of existing equipment, materials, and personnel; it is a practical and constructive program which should facilitate the solution of some of our vital industrial and economic problems. Essentially, it is an engineering book that is largely devoted to methods of management. The author cites many examples of what has been done in certain plants as a means of telling what can be done to accomplish a desired result.

The author takes up in order an analysis of the power industry by analyzing its elements such as location and equipment of plants, mastering of materials, maintenance, labor problems and compensation, and processes, analysis of performance and expenses, and finally the consideration of power as a commodity.

PROTECTIVE RELAYS, by Victor H. Todd; first edition, size 5½ by 8; cloth, 274 pages, 244 illustrations; New York, N. Y., 1922

Protective relays have come to occupy such an important place in electric power systems that we welcome a book devoted exclusively to the subject. From the makeshift device of former times the protective relay has grown to be a marvelous device, almost endowed with reasoning or thinking powers, without which our large interconnected power systems of today would be seriously handicapped.

In this book the author has covered the subject from the first principles of protective relays to the protection of high tension net works, the object being to make the work of value not only to the operator and tester who has a fair knowledge of electricity and is seeking more information, but also to the designer of the system who may find many points not previously taken into consideration in his calculations.

Some of the material was published in the form of articles by the author in various technical periodicals.

A partial list of chapter headings may serve to give the reader an idea of what the book contains. These are as follows: What are protective relays? Circuit breakers and releases. Trip circuits and time delays. Plunger protective relays. Direct current power-directional relays. Applications of direct current power-directional relays. Induction-type current relays. Alternating current power-directional relays. Characteristics of alternating current disturbances. Instrument transformers and groupings. Protection of parallel feeders. Miscellaneous relays. Testing direct current and alternating current relays. Locating faults in feeders and wiring.

IN TECHNICAL PAPER 284, "Coal and Coke Mixtures as Water-Gas Generator Fuel," by W. W. Odell, gas engineer, just issued by the United States Bureau of Mines, are given the details of studies recently made at Davenport, Iowa, in co-operation with the Illinois State Geological Survey and the Engineering Experiment Station of the University of Illinois, in which satisfactory results were obtained with the use of coke and Illinois bituminous coal in the manufacture of water gas.

The experiments conducted at Streator, Ill., by the Bureau of Mines and the Illinois Geological Survey, in 1918, in operating a 6-ft. set 6 to 7 hr. a day, did not solve some of the important questions in the use of coal fuel, namely, the effect of a stand-over period on capacity and possibilities in the use of the blow-run method of operating with mixed fuels, coal and coke. The chief purpose of the present paper, therefore, is to present information bearing on these problems and the results

obtained during six weeks of experiment of Davenport, using mixed generator fuel with the blow-run method of operating. Data are included on the behavior of the various fuels used in the generator, the clinker conditions, the use of fuel high in ash, and on the use of coal high in sulphur.

Copies of this paper may be obtained by applying to the Bureau of Mines, Washington, D. C.

MECHANICAL WORLD YEAR BOOK FOR 1922; 348 pages; 4 by 6, cloth; Manchester, Eng.

This, the thirty-fifth annual edition, has been enlarged by the addition of some 20 pages. The section on Boiler Construction has been largely rewritten and a considerable amount of new material added. A new section on Pipes and Tubes contains a collection of data on pipes of cast iron, wrought iron, steel, and copper, flanged connections, expansion bends, fittings, etc. Tables on the Thermal Properties of Solids, Liquids and Gases have been restored after having been left out of recent volumes. Many other revisions have been effected and a number of new illustrations introduced.

THE ROMANCE OF WIRE ROPE, by John Kimberly Mumford; 137 pages, illustrated. New York. Wire rope is one of those products which are taken for granted. There are few persons who are not familiar with the romance of steel and other large industries of the country, but up to the present the story of wire making in America has never been told. The book is written in a popular vein, understandable to the layman, and in no meaning of the term is it technical. For the most part it relates the growth of wire making as reflected in the growth of the John A. Roebling Sons Co.

It was in 1840 that the first Roebling rope was finished. John Roebling had a vision of the part that wire rope was to play in the industrial development of the world and from the start realized the universal mission of twisted wire.

Wire rope, spreading its field of utility wider and wider, carried with ease and safety loads that "had broken the back of hemp." Roebling by 1844 had not only perfected his theory of wire bridges, but had built a wire bridge as an aqueduct for the Old Pennsylvania Canal, the basins of which were at Pittsburgh.

The summit of achievement in the building of bridges of wire came with the construction of the Brooklyn Bridge, considered the Eighth Wonder of the World. It was while occupied in this work that John Roebling sustained a slight injury that resulted in his death.

This book relates in a vivid way the various processes used, the exacting care necessary and a few of the various uses to which wire rope is put.

Catalog Notes

SARCO PRODUCTS, including steam traps, radiator traps, temperature regulators, thermometers and strainers, are briefly treated in one of Sarco Co.'s recent circulars.

MESTA UNA-FLOW Engines is the title of a 24-page illustrated booklet recently issued by the Mesta Machine Co. This booklet is devoted to a description of the Stumpf Una-Flow engines which the Mesta Machine Co. has been granted license to build in the United States and Canada. These engines are built for all power purposes and many of them are in use in capacities up to 6000 hp.

IN BULLETIN NO. 51, recently issued by the Quigley Furnace Specialties Co., New York City, the method of applying successful boiler setting patches is described and illustrated.

A BOOKLET from the Strong Machinery and Supply Co., New York, illustrates and describes a few Strong specialties including Strong's Ironclad high pressure gage glasses, Rivalate fibrous metallic packing, and I. O. P. high pressure discs for steam valve works.

AN ILLUSTRATED bulletin recently issued by the Erie City Iron Works describes the Seymour pulverizer and furnace. This apparatus is designed for use with unit systems of burning pulverized coal and is extremely simple in construction.

THE WHITLOCK Coil Pipe Co. has just issued Bulletin No. 30 in which is described the Whitlock All Steel Superheater. This represents a comparatively recent addition to the line of heating exchange apparatus manufactured by this company.

CATALOG L of Illinois Stoker Co., Alton, Ill., describes and illustrates Illinois chain grate stokers in two types, natural draft and forced draft, both with dampered air control. Among topics emphasized are air control; the advantages of mechanical stoking and of the chain grate principle; and the Illinois flat suspension arch. Illustrations show applications of the Illinois stoker to various types of boilers.

WESTINGHOUSE turbine generator units are described and illustrated in Circular 1094-B, just issued by the Westinghouse Electric & M'f'g Co., East Pittsburgh, Pa. This publication contains a discussion of the reactance and impulse types of turbines, both the semi-double flow type and the multiple cylinder type. Bleeder turbines and geared turbines are described, and each part of the turbine is elaborately treated. The generator is also discussed in detail, and illustrations are given to show the latest types of construction.

TRADE STANDARDS in the Pump Industry is the title of a booklet which has just been published by the Hydraulic Society, 50 Church St., New York City, of which C. H. Rohrbach is secretary. The book gives the definitions of trade pumps, plain fitted pumps, brass fitted pumps; the standard equipment for a pump, and what are considered extras, typical sizes, and definitions of trade terms such as static head, total dynamic head, static suction lift, dynamic suction lift and others. The booklet shows what the Society and its members think should be the standards of the industry and is recommended to buyers as a guide if nothing to the contrary has been agreed upon, but it is recognized that it will take some time for all of the suggestions to be adopted as accepted standards. Copies of the book can be obtained from the secretary of the Society.